

Vol. 100. Price One Shilling and Sixpence.

A TREATISE
ON
SHIPS' ANCHORS:
FORMING ONE OF THE
RUDIMENTARY SERIES
FOR USE IN THE ROYAL NAVY AND THE
MERCANTILE SERVICE.
BY GEORGE COTSELL, N.A.
With numerous Illustrations.

LONDON: JOHN WEALE.

15.8.619

A

TREATISE
ON
SHIPS' ANCHORS.

BY GEORGE COTSELL, N.A.

With numerous Illustrations.

LONDON:
JOHN WEALE, 59, HIGH HOLBORN.
1856.

LONDON:

PRINTED BY JOHN WEALE, KING'S HEAD COURT, GOUGH SQUARE.

TO THE READER.

THE subject-matter of this work has already been brought under the notice of the public in general; and many persons have been led to form their opinions upon it almost exclusively from information obtained through the agency of the newspaper press.

Some erroneous and *ex parte* statements have been made, which have tended greatly to mislead the public mind. Very few persons, comparatively, have any means of ascertaining the amount of credit to which such statements are entitled, any more than they have of determining the merits of the question brought under discussion.

A large portion of the class above referred to will be found to place so much reliance on what they read in the papers, particularly when directed against the *personnel* or *matériel* of public departments, that there is but small ground for hope of obtaining a verdict at their hands different from that they may have already come to. Yet the path of duty of a public officer will be so clearly defined, that, amid the heavy blows and great discouragements he may meet with, he betakes himself to that duty—proclaims the truth and corrects error.

Having arrived at the head of his trade, the author

is not open to the charge of seeking his own advantage in the prosecution of the work, having nothing to gain in the way of promotion. Without, however, looking either to the right or left as regards any benefit that could by possibility accrue to himself in the matter, he has a consciousness of right in the course now pursued, which is more than sufficient inducement for the performance of a duty he owes to the service and the public, by faithfully putting upon record those facts upon which he hopes to ensure the co-operation and support of all such persons, of whatever rank or station, as are qualified to form an opinion on the subject; and to soften down or modify the opinion of those whose opportunities have been so few and far between (and those few mostly of a questionable character), as to prevent the possibility of their being able to arrive at any fair conclusion of the numerous points involved in the question under discussion.

Whilst excluding none from entering into the merits of this question, the author is desirous of arresting the attention and consideration in particular of those persons who are in any way concerned in *the use, construction, or manufacture of anchors*; and should he be fortunate enough to succeed in this, there can be no doubt that, sooner or later, the public will be benefited.

It is intended, as far as practicable, that the progress of anchor-making during the last fifty years should be duly considered and set forth in these pages, without adding unnecessarily to the cost of the work.

The difficulty of obtaining access to authenticated

documents in the public offices, and the absence of any of note in other quarters, will occasion some omissions, and might lead to some disappointment, but the object has been to render the work as complete as possible.

The subject of these pages has for many years occupied in no small degree the author's attention; and he had previously prepared a work on the subject, when the appointment of the Committee of 1852 was announced. It became necessary, in consequence, to delay its publication for the Report of that Committee, in which is contained an invitation to others to discuss the question, which invitation he most cordially accepts.

The Report of the Committee rendered it necessary that the work, the author of these pages had previously prepared, should be reconstructed. The facts are unaltered: and his deductions have received singular confirmation by the labours of that Committee.

The delay in publishing it has been, in most cases, occasioned by circumstances over which the author had no control. Indeed, the labour and difficulty of the work itself, and the discouragements he has met with, even in quarters where he calculated, and not, he conceives, unreasonably, for support, must be his apology for the delay in bringing it before the public. The absorbing topic of the war with Russia must also be mentioned as having, in no small degree, retarded the progress of the work. Policy, also, dictated delay; as it could hardly be expected that a work of this nature could find a place in the public mind, when it had evidently been overcharged with one of infinitely greater import.

As there appears, however, a disposition in other

quarters to again agitate this question, and as the means now employed by the parties referred to are unfair, and as derogatory to truth as those previously promulgated, these the author conceives to be strong reasons for no longer withholding the publication of this work, which he would now respectfully submit for the consideration of the public.

The author would impress on the reader's attention to regard the *anchor* as a machine whose principles are identical with those of common sense; and that any attempt to discuss the question on other grounds can serve no purpose but to mystify and lead away the judgment.

Finally, the author believes—nay, feels certain—that all the defects charged from time to time against the *Admiralty anchor* would soon cease and determine, could the Admiralty devote sufficient time to the consideration of the subject to master the details; but as their onerous and multifarious duties do not admit of their doing so, the author hopes that this attempt to supply a deficiency on a highly interesting and important subject will be as useful and agreeable as it has been honestly conceived. For the discursive character of the work, the author makes no apology, it being altogether the result of circumstances to which the work itself owes its origin.

JE MAINTIENDRAI LE DROIT.

EXTRACT.

"The Times," Monday, 9th April, 1855.

"Much surprise and some discontent prevail in the Navy, especially with those officers who have a second time been sent out in the Baltic fleet, at the continued reissue of the old-fashioned and 'established'

anchor, or, as it is more familiarly called, the *Admiralty mud-hook*, after the practical experience resulting from last year's cruise in the Baltic, and demonstrated by the heaps of broken anchors (about £60,000 worth!) returned into store at the various dockyards from the several ships, comparable in trustworthiness and utility to the wretched intrenching tools supplied to our army before Sebastopol."

There was so much cunning evinced in the way in which the above was got into circulation through the medium of "The Times," by being tacked on to the foot of a paragraph of a totally different subject, and the statement being of so extravagant a character, that I felt anxious to obtain, through an official channel, the actual state of the case. It appeared to me, that to publish this work without meeting a statement of this kind, fairly and fully, would render me obnoxious to censure. Official people in general seem to think that, because they know the statement to be false, it is unworthy any notice. It is this rule of conduct that has contributed materially to embolden slanderers. They know that there is a certain impunity they can calculate upon, and hence they recklessly hazard all kinds of falsehoods, well knowing that the great bulk of those addressed neither know nor care to ascertain the truth of the facts stated.

My feeling is, that falsehood of every kind should be promptly exposed, through the same medium as the slander was propagated; how much of the scandal that now unhappily attaches to public men and to public departments might have been prevented, if some pains had been taken to set the truth in all cases before the public eye.

Well, then, as to the paragraph in question, it only remains to notice—

First,—That *all* the anchors supplied to the Baltic Fleet, of every size and description, were not worth HALF “£60,000!”

Second,—That only a very few were broken; that the fractures had no reference to or bearing upon the *plan* of the anchor, but to circumstances, partly local, partly to defective workmanship; and that *one* thousand pounds would be the outside of the damage sustained—NOT £60,000!!

Casualties are but the natural consequences of such a service as that to which the Baltic fleet was appointed. That some of them *might* have been avoided by more careful and skilful workmanship, and possibly, by more judicious handling, is probable. The case was trumped up to serve an interested purpose, not to benefit the public, and is therefore to be condemned. Anchors and *cables* suffered equally—as well they might in such a sea. Where was the justice or propriety, or the regard for truthfulness, in singling out the Admiralty anchor for condemnation and reprobation, and uttering not even a word as to the breakages of chain cables?

I have not been enabled to give a list of the casualties; but the reader may be assured, that the damage sustained by the breaking of the anchors referred to is not understated by myself.

I think, therefore, that the lovers of truth and fair play will not be slow to admit a justification for the course I have thought it incumbent upon me to pursue.

CONTENTS.

PART I.

	Page
<u>On anchors in general</u>	1
<u>Ships' anchors</u>	1
<u>The component parts of the anchor described under the several appellations by which they are known in "The Service"</u>	5
<u>Old plan long-shanked anchor</u>	7
<u>Anchors on Mr. Pering's plan</u>	12
<u>Admiralty anchor</u>	15
<u>Lieutenant Rodger's anchor</u>	17
<u>Captain Hall's patent portable anchor</u>	23
<u>Cotsell's portable and mooring anchor</u>	25
<u>Porter's patent anchor</u>	27
<u>Cotsell's improved portable anchor</u>	31
<u>Hutchens' portable anchor</u>	37
<u>Morgan's and Little's portable anchor</u>	39
<u>Hawkins's patent anchor</u>	41
<u>Numerous inventions and suggestions</u>	43

PART II.

<u>The appointment, constitution, and report of the Committee of 152, considered</u>	45
<u>Extract from Porter's pamphlet</u>	62

	Page
<u>Disparity in the shank and arms of the anchors known as Porter's, Rodger's, and the Admiralty</u>	64
<u>Test at Woolwich yard</u>	68
<u>Table of approximate values</u>	71
<u>Properties essential to a good anchor, with their approximate values as reported by the Committee, considered</u>	74
<u>Approximate values</u>	84
<u>The alleged inefficiency of the Admiralty anchor considered; the causes which have led to its inefficiency, and the means of prevention, explained</u>	88

PART III.

<u>Cotsell's construction for an improved Admiralty anchor</u>	95
<u>On anchor-making</u>	97
<u>Table (A) of proof-strains, &c., of anchors</u>	103
<u>Table (B) of proof-strains of chain cable, &c.</u>	104
<u>Testing</u>	104
<u>Annealing</u>	110
<u>Stocks for anchors—General dimensions, &c.</u>	114
<u>Proposed alteration of Porter's anchor</u>	121

ILLUSTRATIONS.

<u>Sketches A and B—Anchors in use fifty years back</u>	2, 3
<u>Plate 1—Component parts of the anchor</u>	4
<u>Plate 2—Old plan long-shanked anchor</u>	6
<u>Plate 3—Pering's first anchor</u>	10
<u>Plate 4—Pering's improved anchor</u>	11
<u>Plate 5—Admiralty anchor</u>	14
<u>Plate 6—Lieutenant Rodger's anchor</u>	16
<u>Figs. A, B, C, D—The loophole, The pickaxe anchor, Arms and crown</u>	19
<u>Measurement of contents of holding surface, &c.</u>	20
<u>Dutch palm, &c.</u>	21
<u>Plate 7—Captain Hall's portable anchor</u>	22

	Page
<u>Plate 8—Fig. 1, The half of Captain Hall's anchor for use as a mooring anchor; Fig. 2</u>	24
<u>———Cotsell's portable anchor for use as a mooring anchor</u>	24
<u>Plate 9—Porter's patent anchor</u>	26
<u>Sketches <i>a</i> and <i>b</i>—Palm and horn</u>	28
<u>Plate 10—Cotsell's improved portable anchor</u>	30
<u>Plate 11—Fig. 1, Sketch of part of Admiralty anchor; Fig. 2, Sketch of a fish-hook; Fig. 3, Arm badly curved, destructive of nipping and holding properties</u>	32
<u>Plate 12—Hutchens' portable anchor</u>	36
<u>Plate 13—Morgan and Little's portable anchor</u>	38
<u>Plate 14—Hawkins's patent anchor</u>	40
<u>Sketches <i>x</i> and <i>y</i>—Shank, crown, &c.</u>	42
<u>Sketch <i>o p</i>—Crown, &c.</u>	43
<u>Plate 15—Isaac's anchor</u>	47
<u>Plate 16—Mitcheson's</u>	48
<u>Plate 17—Lenox's</u>	49
<u>Plate 18—Honiball's or Porter's</u>	50
<u>Plate 19—Aylen's</u>	51
<u>Plate 20—Rodger's (bower)</u>	52
<u>Plate 21—Trotman's (improved Porter's)</u>	53
<u>Plate 22—Admiralty</u>	54
<u>Relative proportions of four anchors in store at Chatham yard; Relative dimensions of the palms, &c.</u>	63
<u>Plate 23—Diagram showing comparative length of shanks, arms, &c.</u>	75
<u>Plate 24—The actual obstruction presented by the upper arm of Porter's and Trotman's anchor's as compared with that of the Admiralty</u>	78
<u>Plate 25—Length of several arms and the angle in each case</u>	80
<u>Plate 26—Angle of arms, &c.</u>	83
<u>Plate 27—Figs. 1, 2, 3, The kind of arm adapted to the present Admiralty anchor; Figs. 4, 5, The malformation of the points of the anchor</u>	90

	Page
<u>Plate 28—Probable results of an undue curvature of the palm near the point.</u>	91
<u>Plate 29—Cotsell's improved Admiralty anchor</u>	94
<u>Sketches a, b, c, d, d—Sectional forms, &c.</u>	98
<u>Sketches a, b, c—Scarfs of the shank—Tyler, Officers of Devonport yard, Cotsell</u>	100
<u>Plate 30—The several component parts of an anchor as forged at the steam hammer, ready for the anchorsmith</u>	101
<u>Grooved anvil, &c.</u>	102
<u>Plate 31—Stocks, &c.</u>	116
<u>Sharp-edged stocks, and injury to chain cables</u>	117
<u>Plate 32—Cotsell's iron anchor-stock—Fig. 1, square of the shank, with the pin in the stock-hole; Fig. 2, Revenue view of the shank with the stock in place</u>	118
<u>Plate 33—Fig. 1, Porter's flukes in their present form; Fig. 2, His flukes as altered for <i>Cleopatra</i></u>	120
<u>Plate 34—Figs. 1 and 2, Porter's shank in its present form; Figs. 3 and 4, His shank as altered for <i>Cleopatra</i></u>	122

A TREATISE ON SHIPS' ANCHORS.

PART I.

ON ANCHORS IN GENERAL.

ANCHORS are of two kinds—*Solid* or ordinary, and *Portable*.

The *Solid* or ordinary anchors are those which have the shank and arms wrought into one body, or mass, at the crown of the anchor. See Plates 1, 2, 3, 4, 5, and 6.

The *Portable* anchors are those which admit of being separated, or taken to pieces. These are of several sorts. See Plates 7, 8, 9, 10, and 11.

Anchors are known under the denominations of "Wood-stocked," and of "Iron-stocked;" also as "Bower," "Stream," and "Kedge."

It is intended to treat, in the first place, of *Anchors*; and, subsequently, of *Stocks*.

Ships of the Royal Navy are supplied with

- 4 Bower Anchors,
- 1 Stream Anchor,
- 2 Kedge Anchors,
- 3 Chain Cables,
- 1 Hempen Cable.

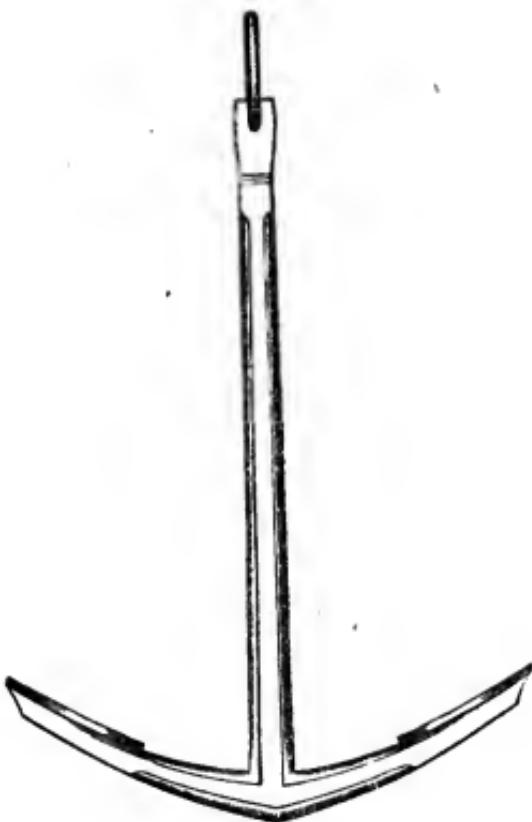
The length of each cable is 100 fathoms (600 feet).

N.B. An additional chain cable is sometimes supplied to "Line-of-Battle" ships.

SHIPS' ANCHORS.

The subject is treated of chiefly as respects the Anchors used in the British Royal Navy and Mercantile Marine; other nations having, no doubt, adopted such improvements as their several necessities required. Still, whatever is worthy of note in these pages as respects England, will not, possibly, be altogether lost to other States; there is no reason why the subject-matter should not have a universal application.

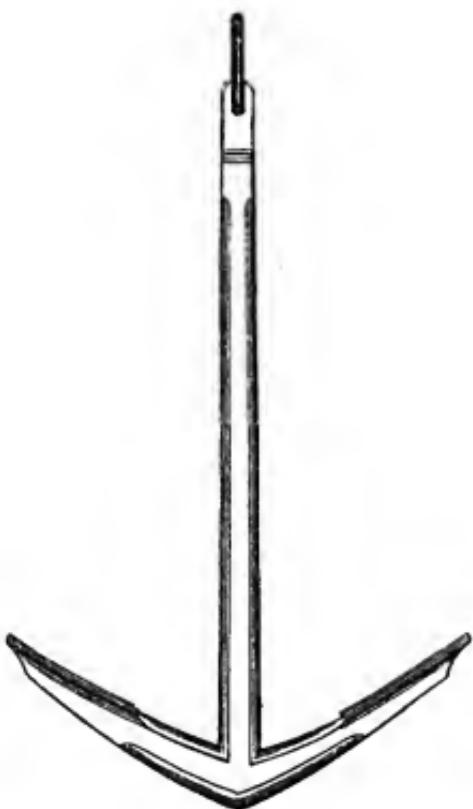
Sketch A.



The sketch A represents the anchors used in the Dutch, Danish, and Swedish Navies fifty years ago.

The sketch B, that of the French Navy at the same period. The chief peculiarity of this is its extremely sharp-angled *throat*: with this exception, the French anchor differs but little from that of the English anchor of fifty years ago. See Plate 2.

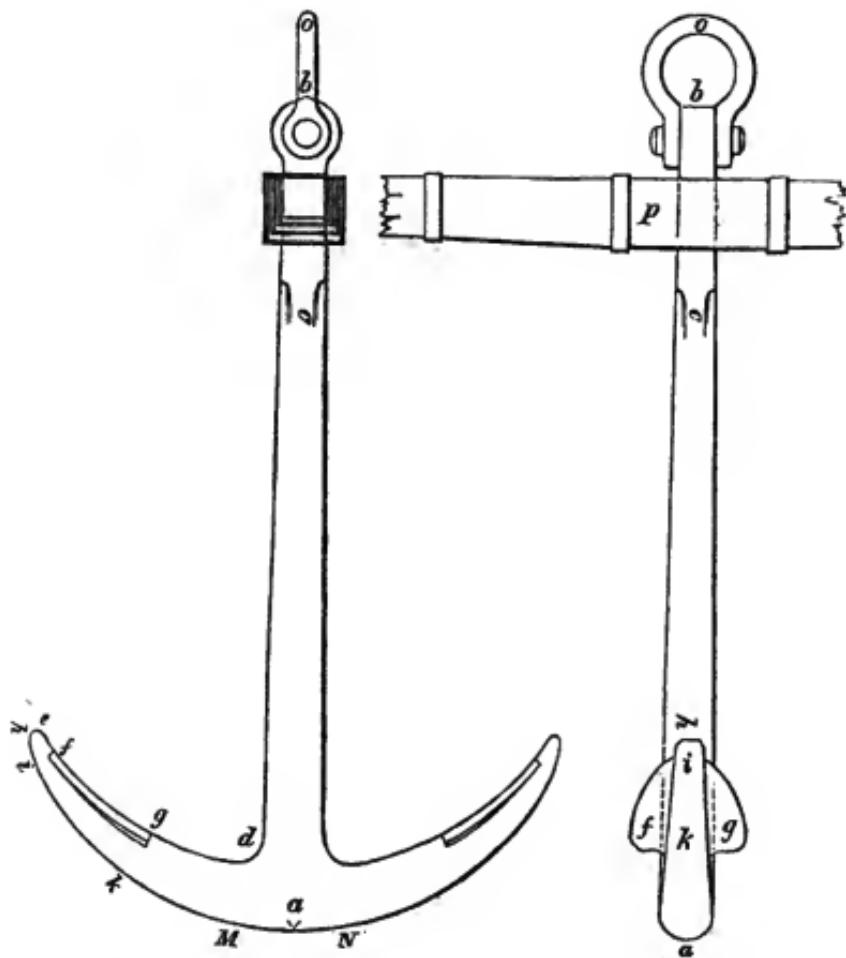
Sketch B.



The intercourse between civilised nations, which commerce tends to bring about, will have paved the way for the adoption by one nation of the improvements of another, and particularly so amongst the fitments of shipping; hence we may presume that, in the matter of anchors, no great difference will be found to exist between those in general use in European nations.

PLATE 1.

Showing the component parts of the Anchor.



The Component Parts of the Anchor described under the several appellations by which they are known in "The Service."

(Plate 1.)

THE SHANK

is all that part of the anchor extending in a straight line, from *a* to *b*.

THE SQUARE

is that part of the shank which extends from *b* to *c*; to which the "Stock" and "Shackle" are attached.

THE ARM

is that part of the anchor which extends from the "throat" (or "crutch") to the extreme end, from *d* to *e*, including the "Palm," the "Point," and the "Blade."

THE PALM

is that part of the arm, of a shield-like form, from *f* to *g*, and constitutes the "holding" surface of the anchor.

THE POINT (PEE, OR BILL)

is that part of the arm commencing at the termination of the "Palm," to the extreme end, from *h* to *i*.

THE BLADE

is that part of the arm at the back of the palm, from *i* to *k*, which in the old anchor was always square, or rectangular; in the Admiralty anchor it partakes of the same section as the "Arm."

THE CROWN

is that part of the external arch upon which the anchor falls when "let go" in a vertical position; and may be said to extend from *M* to *N*.

THE RING (OR SHACKLE),

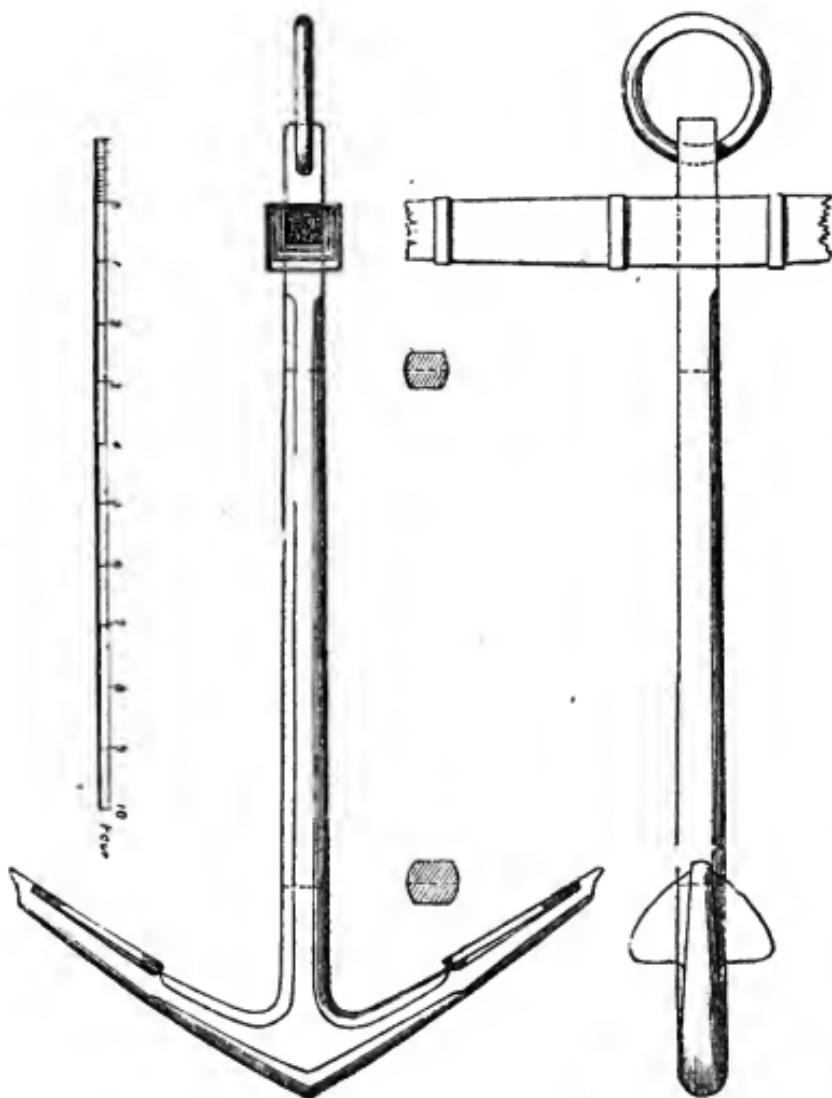
o, is the appendage to which the cable is attached to the anchor, by means of a shackle on the end of the cable, called the "Anchor Shackle."

THE STOCK,

p, is the transverse beam which cant the anchor when the arms fall in an horizontal instead of a vertical position. The Stock is either of wood or iron.

PLATE 2.

Old plan long-shanked Anchor.



OLD PLAN LONG-SHANKED ANCHOR.

(Plate 2.)

It is now upwards of forty years ago that Mr. Pering first drew the attention of the Navy-Board to the defective character of the "Old Plan Long-shanked Anchor," the only one then in use in the Royal Navy; the chief or only complaint recorded against it was, that it was frequently broken.

In his "Treatise on Anchors," Mr. Pering has furnished some account of the casualties in this respect which came under his own observation in Plymouth Yard, during the late war. His position as a Clerk in that establishment afforded him the opportunity of collecting the facts.

In page 30 of his work he says—

"Hundreds of broken anchors repaired in Plymouth Dock-yard, as well as numbers repaired in other Yards, demonstrate to conviction that there must be something wrong in the workmanship, undue proportion, or the manner of combining the materials."

"Continued complaints from Commanding Officers of the Navy on this score, furnish additional proofs of the fact."

"The un-mooring of a fleet has too frequently been attended by the breaking of anchors, both in our own and in foreign ports."

These remarks are important, and will be the basis, in connection with other facts, of the inquiry now proposed to be made in reference to the casualties referred to.

To Mr. Pering belongs the honour of clearing the way for the improvement of the anchor; and, however mortifying to mechanical men this fact may be, it would be the height of injustice not to make honourable mention of him in a work of this description.

That he was much indebted to the practical man in carrying out his suggestions, is quite true; but this in no way lessens the quality or amount of the honour due to him for the judgment he displayed, and the attention he bestowed, in the prosecution of improvements that paved the way for all after-comers.

The quality of the iron used in anchor-making fifty years ago was very inferior, and in size much too small for such a purpose; which, no doubt, led Mr. Pering to recommend that iron of a better quality, and of larger dimensions, than had previously been known in the service (as Rolled Bar) should be in future introduced for anchor-making.

Even the Old plan anchors would have broken less frequently had they been formed of such material as that of which Mr. Pering's anchors were subsequently made.

Then, again, the means of effecting sound and efficient "welding," in large bodies of iron, were wanting; in fact, it would appear, from the then existing practice, that an opinion must have prevailed to the effect that *surface welding* was all-sufficient. However, one thing is certain, that, in "bringing-on" the *arms* to be welded to the *shank*, no adequate force of *blow* for such a purpose could be obtained at the period referred to. Looking at the description of "Hercules" then in use, and the large body of iron at the *crown* to be operated upon, we cease to wonder at the amount of fractures in anchors of the old make so much complained of.

With reference to their *proportions* we might also take an exception; for example, the *palms* of the anchor were very large, and presented a great *holding* surface; much greater, indeed, than was consistent with the defective or inadequate means then in use for manipulating the other portions of the anchor: consequently we find that in *un-mooring* a fleet the breaking of anchors was very frequent, both in our own and in foreign ports. When, therefore, the bad quality of the iron used, the want of adequate means for efficient welding, and the undue proportion of the *palms* relatively with the other parts of the anchor, are taken into the account, the fractures appear but the natural consequence of such a state of things.

One important fact in connection with the working of the Old plan anchors must not be overlooked (as we shall have to notice it in treating of the working of anchors of a more recent date, particularly that known as the Admiralty plan); namely, that they never failed to *nip* and *hold* well; two qualities indispensable to a good anchor.

More of these anchors were broken in the process of "weighing" them than in any other. The *arms* being straight, and the *palms* having a large *holding* surface, an immense amount of strain was thus brought upon the crutch of the anchor, and when it had become deeply imbedded in the anchorage it was no uncommon occurrence to find that it came up deficient of an arm; and sometimes the shank would break, leaving both arms behind, there being no tendency in the anchor to relieve itself. This defect is obviated by the introduction of the *curved* arm of the present day; which owes its origin to Mr. Pering. We must not be un-

mindful that the "Old plan Long-shanked Anchor" was esteemed a wonder in its day, and not altogether undeservedly so, if we also bear in mind that the aid of machinery (except of the rudest kind) was altogether unknown in the smitheries of the Royal Dock-yards, and that whatever defects the anchors in general exhibited those made in *the Service* were much superior to those made by contract.

The contract-made anchor was generally composed of very crude iron, and was less efficiently welded than those made in the Dock-yards.

It is important to notice Mr. Pering's experience on this point, recorded in pages 42 and 43 of his "Treatise," where we find—

"To show further how very improperly anchors have been formed, a piece of an anchor was hung up in the smithery of Plymouth Dock-yard, with the following inscription:—

"Part of anchor of 43 cwt. returned from the Loire, January, 1811, made by contract under the firm of _____. This is their twenty-third anchor reported to the Navy Board, from Nov. 1811 to 1819."

"How many anchors were in a like state in other Dock-yards, I have not the means of ascertaining; but that a large proportion of the contract anchors is very bad (as well as many made in the Dock-yards) is too true. Some hundreds of the former have proved defective on trial, and are laid aside; and so reprehensibly negligent have the workmen been in some instances, that by heating the anchors only in the crown they have fallen to pieces of their own weight, both arms dropping off without a blow!"

And the inducement in the private trade to use inferior iron was the vast difference of price, ranging, as it did, from "£8 to £20 per ton!"

The very defective character of the Old plan anchor I am enabled to corroborate from actual observation, in having, at Chatham Yard, cut up some 200 of them into billets for remanufacture; in the course of which such defects, both of iron and workmanship, were exhibited, as in many cases to cause it to be a matter of surprise how they could have held together.

PLATE 3.

PERING's first Anchor.

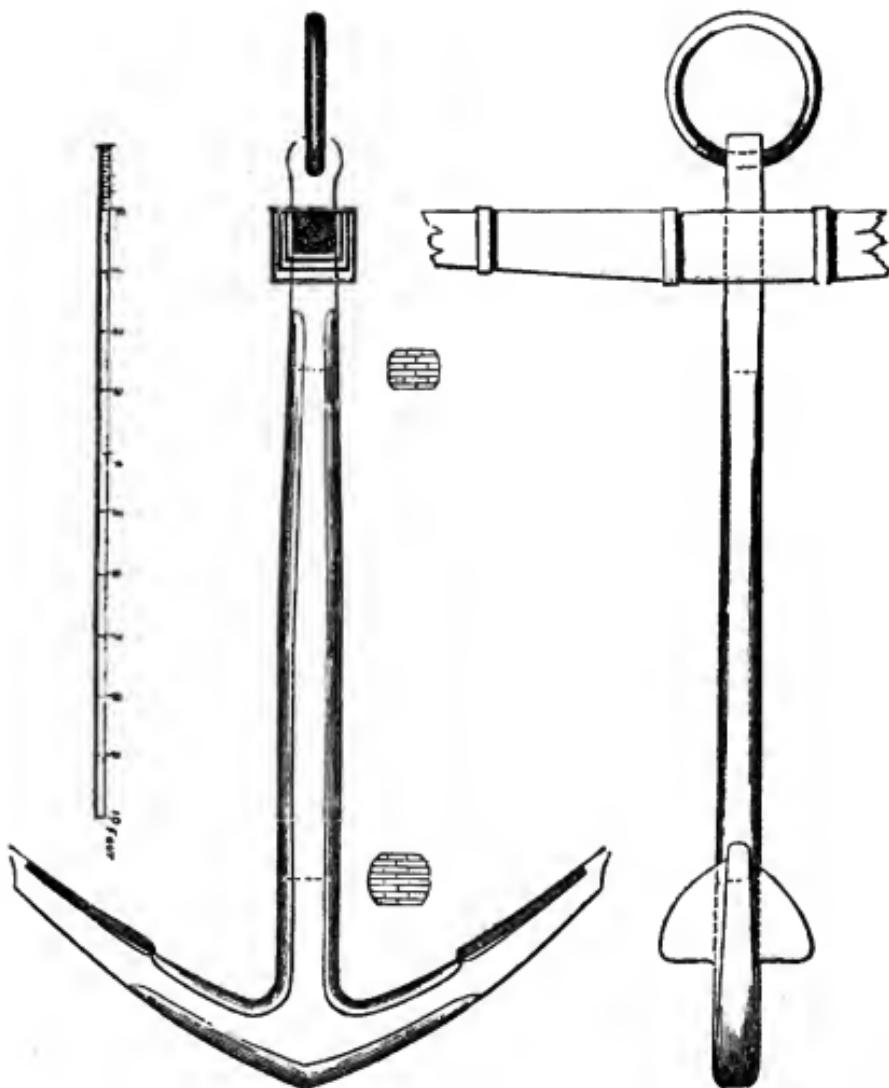
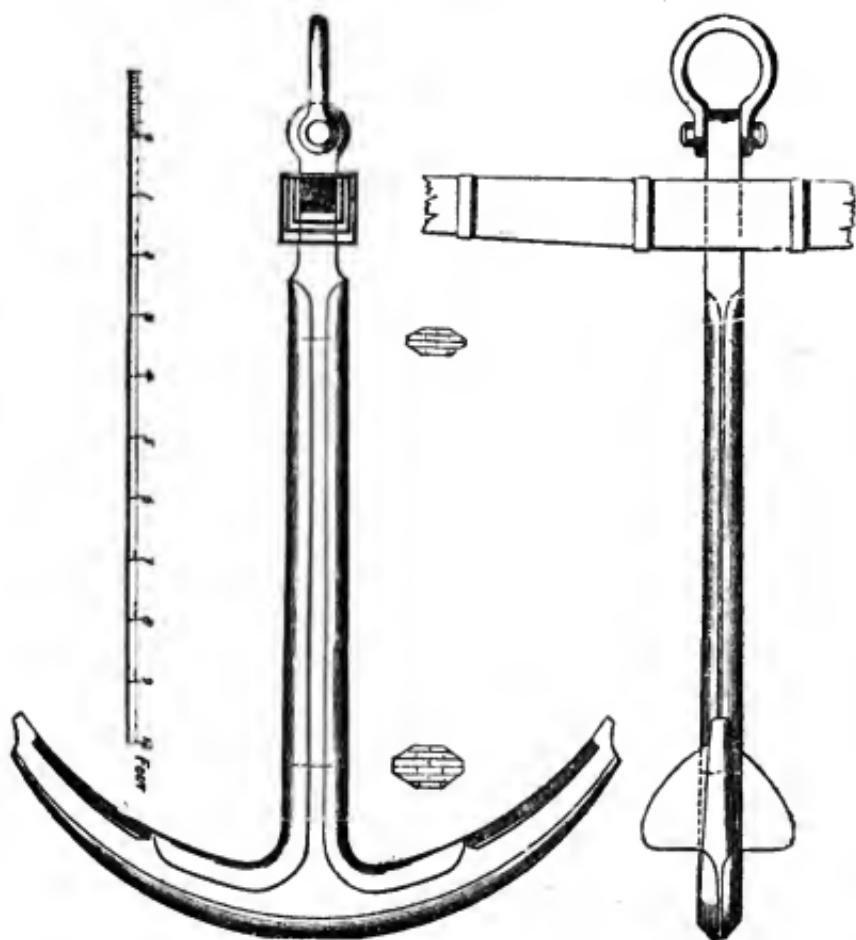


PLATE 4.

PERING's improved Anchor.



ANCHORS ON MR. PERING'S PLANS.

(Plates 3 and 4.)

Mr. Pering's improvements consisted in having iron of a better quality and of larger dimensions for anchor-making; in so disposing the bars of which the shank and arms were composed, that their edges were made to resist the lateral strain brought upon the anchor when in use; in having those bars, when first brought out of the fire, welded by means of the "Hercules" instead of the sledge-hammers; in forming a cross or crown-piece separately, on the principle of a truss-beam, which was subsequently shut to the shank just above the *trend*, and the arms shut to the cross midway between it and the *palm*; in having the arms slightly curved instead of being straight; and in having the sectional form of the shank and the arms oval, slightly flattened at the sides, instead of being nearly round as heretofore. See Plate 3.

Other improvements were subsequently introduced by Mr. Pering, as exhibited in Plate 4; namely, in the *sectional* form of the shank and arms of the anchor, which were so formed as to nearly resemble a diamond, instead of an oval or ellipsis. The avowed object of this latter alteration was to still further increase the strength of the anchor in the line of the strain. It is doubtful if this was attained; certainly it was not attained in all cases. The difficulty of forging anchors of this form was great, and often resulted in defective workmanship, owing to the action of the fire on the edges in the process of being heated.

A new table of dimensions was also introduced, in which the relative lengths of the shank and arms of the anchor were considerably altered. These were known as "Pering's Improved Anchors," with "Short Shanks and Long Arms." See Table of Dimensions, March, 1832.

For a period of nearly twenty years Mr. Pering appears to have had the undivided honour of anchor-improvements; but, as in other pursuits, rivals soon entered the field, and from Mr. Pering's time to the present the subject has never been allowed to slumber; and yet men have been found hardy enough to avow,

"That the anchor had undergone *no change*, and that those now in use are of nearly the same construction as Columbus had in his little squadron when he discovered a New World!"

Great as were the improvements introduced by Mr. Pering, both in the mode of construction and in the form of the anchor, they were only partially successful, owing to the absence of mechanical power in the smitheries for insuring sound and efficient workmanship; and it must ever be borne in mind, that those who followed Mr. Pering had all the advantages, in favour of their several inventions, arising out of the introduction and use of highly improved modes of manufacturing anchors, and to which the success of recent inventions is, in some measure, referrible.

To those unacquainted with the subject of anchor-making, and whose knowledge of the kind of machinery in use thirty years ago was derived from an occasional visit to the smitheries, it may not be out of place here to notice the improvements that have been introduced for rendering the execution of heavy iron work, and of anchor-making in particular, less laborious to the workmen and more efficient.

Let the mention of the following suffice :

The application of steam power to work the Hercules, instead of employing thirty or forty men to work it, as had been the case up to about the year 1830,—

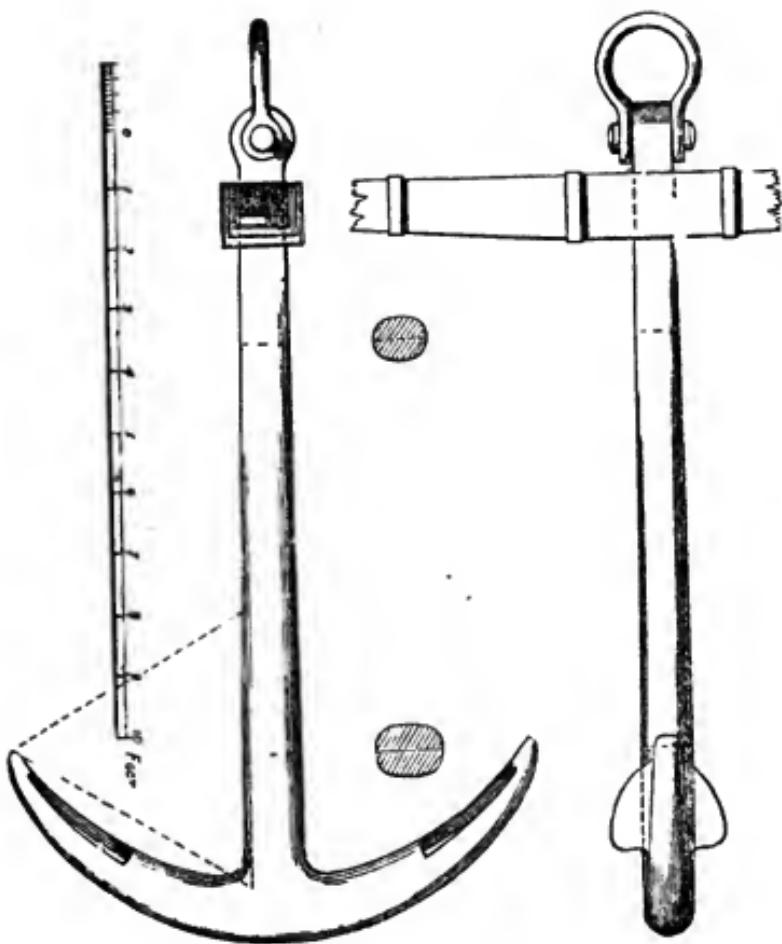
The substitution of the "Fan Blast" for that of Bellows,—The introduction of Tilt, Lift, and Nasmyth's Hammers, in connection with air furnaces, for the larger descriptions of smiths' forgings,—leave us without any excuse for bad or inefficient workmanship.

The value of these appliances in smiths' work is above all calculation. To say that the work has been improved, and its execution accelerated, is only saying a part of what belongs to the subject; the workmen themselves have improved in *status* in proportion as the slavish and degrading drudgery of the work has been lessened by the introduction of steam machinery into the Dock-yard smitheries.

Most of Mr. Pering's suggestions on the subject of anchor-making arose out of the absence of mechanical power for efficiently executing the work. Hence we find that those suggestions, valuable in his time, are no longer of any great value; the process of anchor-making having entirely changed with the improved character of our machinery. As a proof of this, Mr. Pering's anchors are found incompetent to sustain the effects of the "proof strain" as applied to anchors of the present day; and an order has been given to the effect that only 75 per cent. of the Admiralty scale of *proof strain* is to

PLATE 5.

Admiralty Anchor.



be put on anchors of Mr. Pering's plan. And one anchor only, as a *Bower*, of Pering's make is issued to ships fitting out, thereby insuring three of a more modern construction to each ship. The cost of production has also been considerably reduced simultaneously with the improvement of the anchor. Anchors are now made at 50 and even 60 per cent. less cost than those on Pering's plan.

A most singularly curious opinion was advanced by Mr. Pering relative to the perfection and efficiency of anchors made on his plan. See Pering's "Treatise on the Anchor," pages 52, 53 :—

"If the observations here introduced be attended to, and the anchor manufactured with iron of the first quality and according to the proportions given in the Table, it will be a rare instance to hear of an anchor giving way; indeed, I may venture to say, that such an occurrence cannot take place!"

These remarks were published in 1819, and in a few years after we find Mr. Pering introducing an "Improved" anchor (Plate 4). Mr. Pering saw that his anchors did break, and therefore sought to supply another anchor of greater strength than his first; and even this, like all anchors, did and must break, when subjected to a strain beyond its power of resistance.

ADMIRALTY ANCHOR.

(Plate 5.)

About fifteen years ago this anchor made its appearance in "The Service" under the auspices of the Admiralty Board. It has often been known under the denomination of "Sir William Parker's Anchor."

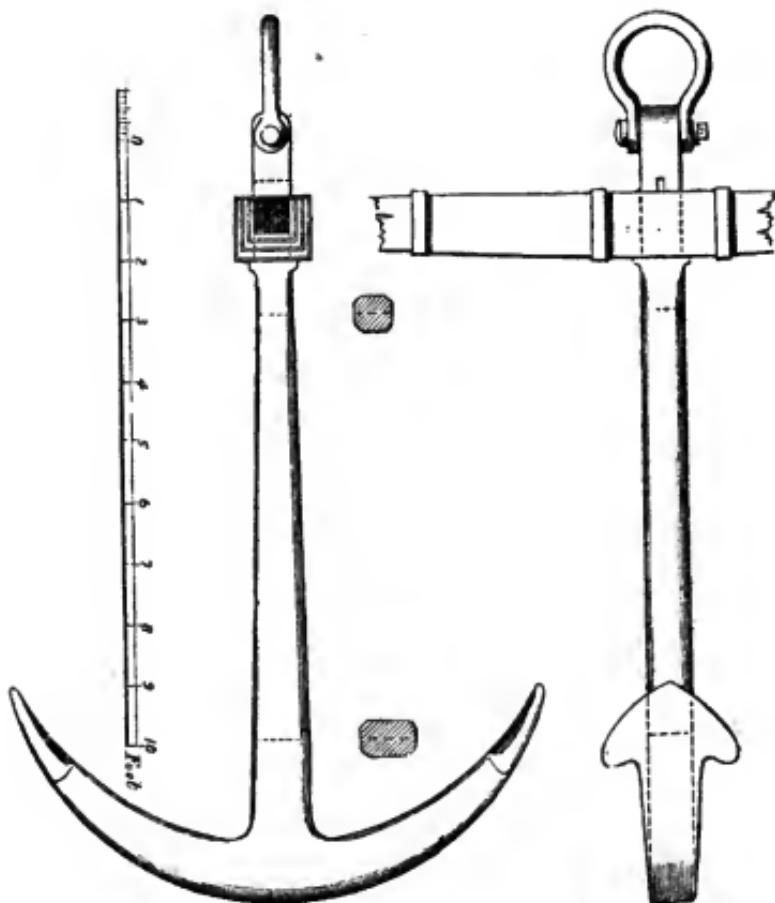
From the period referred to it has been very extensively used in the Royal Navy.

The general character and appearance of this anchor are greatly in its favour over those of a previous date.

The attention of the authorities would appear to have been directed to the subject of the improvement of the anchor, owing to the great and rapid enlargement of our ships of war: ships of an experimental character were being introduced about this date, and pointed to the necessity for increasing the efficiency of the anchor.

PLATE 6.

Lieut. RODGER's Anchor.



The elliptical form of the shank and arms, together with the elegantly curved "crown" and "arms," the diminution of the superficies of the "palms," the absence of sharp edges (preventing injury to the cable), caused this anchor to be received with general favour by the mechanical man, as well as by officers of the Navy.

Notwithstanding, this anchor has been the subject of severe criticism and condemnation.

The subject of its merits and demerits must be discussed hereafter; and it will, consequently, be unnecessary to enter more particularly at present into the grounds for its *condemnation*; yet it may be safely asserted, that instances are on record in which this anchor has proved itself of the greatest possible efficiency under circumstances of the severest possible nature; and it will be gratifying to the lovers of truth and fair play to be enabled to examine whether the *principle* of this anchor, so loudly and repeatedly condemned, is or is not worthy of respect, and in what particulars it has failed to perform its office; also to show, by indisputable evidence, to whom, and what, its reported "failures" and "fractures" owe their origin; and what modifications are calculated to be beneficial, should an alteration of this anchor be deemed necessary.

If once eminently successful, why not *invariably* successful? We shall presently see why *not*.

The length of the shank and arms of this anchor are determined relatively; viz., if the length of the arm be 4 feet, the length of the shank will be 12 feet, or as three to one. These dimensions are of very ancient date; the "Old plan long-shanked anchors," as they were called, were of these proportions.

LIEUT. RODGER'S ANCHORS.

(Plate 6.)

It is now some twenty-five years since that Lieut. Rodger first commenced his career in anchor improvements.

About the period referred to we find him exhibiting his "*Patent HOLLOW*-shanked Anchor," the object being to render the shank stronger. The plan was to form a long loop-hole in the shank (the flat way of the shank), which hole was filled with the best oak timber, and some seven or eight hoops were driven on taut over all.

Fig. A.

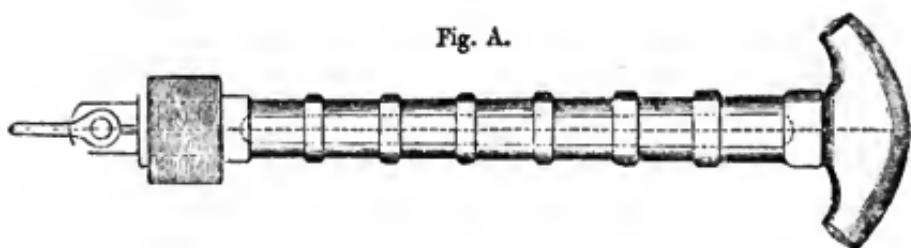


Fig. B.

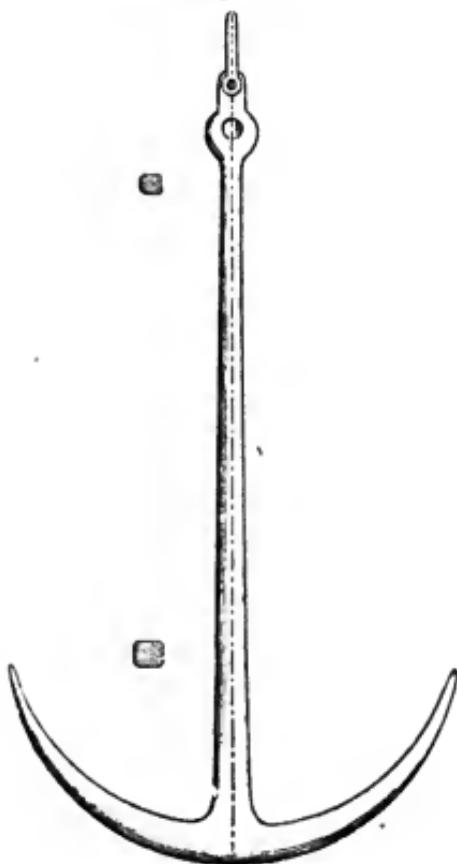


Fig. C.

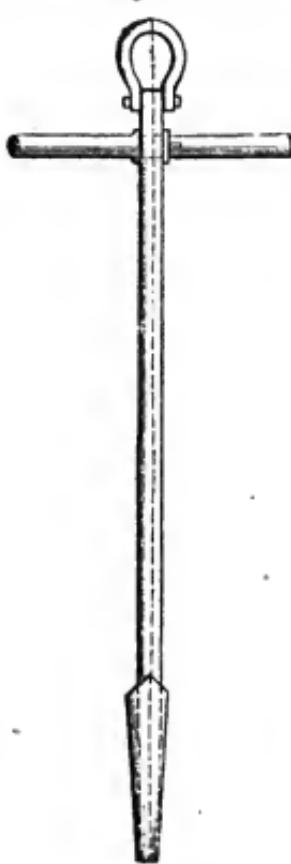


Fig. D.



The loop-hole commenced at about a foot from the throat of the anchor, and terminated at a similar distance from the *square*. (See fig. A.)

An anchor on this plan, of about 25 cwt., was made in Portsmouth Yard; but whatever its merits as to fortifying the shank, no other part of the anchor was improved by it. It involved additional expense; and, *practically*, was liable to be imperfectly wrought, or, what is the same thing, required great skill and attention in forging the "loop-hole" free from defects. It was not calculated for general adoption, and soon fell into disuse even in the mercantile marine. The attempt to strengthen the shank could scarcely be defensible when the arms were left untouched, the shank not having proved less efficient than the *arms*.

Next came his "*Patent PICKAXE Anchor*," an anchor *without a palm*—an extremely bold stroke, particularly for a naval man. The novelty of the *patent* obtained it some attention; and, tried and used under certain favourable circumstances, it appeared to answer; but it was monstrous to suppose that such an anchor could endure. Those brought into the service are regarded as "*obsolete stores*," or are only occasionally thrown into service as a "*kedge*" when the "*store*" of other sorts is exhausted. (*Vide* figs. B and C.)

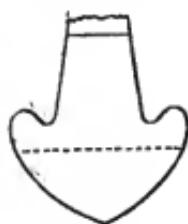
Next we have Lt. Rodger's "*Patent small-palmed Anchor*"; and for several years this said anchor was gradually developing itself, until it exhibited a surface of *palm* so devised that it actually measured, for contents, often as much, and sometimes more, than the palm of the Admiralty anchor. The drawing, Plate 6, represents one of his anchors of 50 cwt. of 1844.

It will be observed that the sectional form of his anchor is rectangular, or rather *was* until this date. Since then, however, we have been favoured with two other alterations or improvements. The one is, that the crown and arms of the anchor are forged of a wedge-like form [supposing a wedge cut in two transversely, the *butt* would be the exact figure of the arms and crown (fig. D)]; the other is the turning of the *palm* "*right about face*"—both alterations doubtless protected by *patents*, and both avowedly for the purpose of obtaining more *holding* surface; a strange acknowledgment from one who set out by asserting that *palms* were unnecessary! The properties of this anchor are discussed under "Report of Committee of 1852."

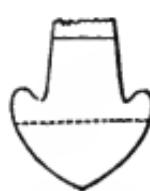
Feet 4·52.



Feet 3·24.



Feet 2·44.



Feet 4·53.



Feet 3·36.



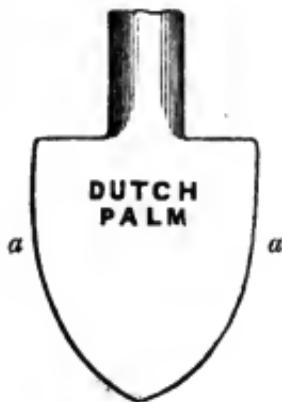
Feet 2·48.



Several of Rodger's anchors were measured for contents of *holding* surface against anchors of the Admiralty plan of similar weights, and their contents were found to be so nearly equal as to admit of no further question that Lieut. Rodger had found that *palms* were necessary.

Then as to the form of the Palms. I have elsewhere observed that the Dutch palm, under some modification or disguises, had been adopted by Lieut. Rodger in his anchor.

The Dutch palm, so called, differs from that of the ordinary palm, inasmuch as it terminates at the extremity of the arm, and not with a point or "pee," as in the Admiralty palm, at *a a*. I have stated elsewhere that the Dutch palm is a very efficient one, and might, with great propriety, be universally adopted. (See Sketch.)

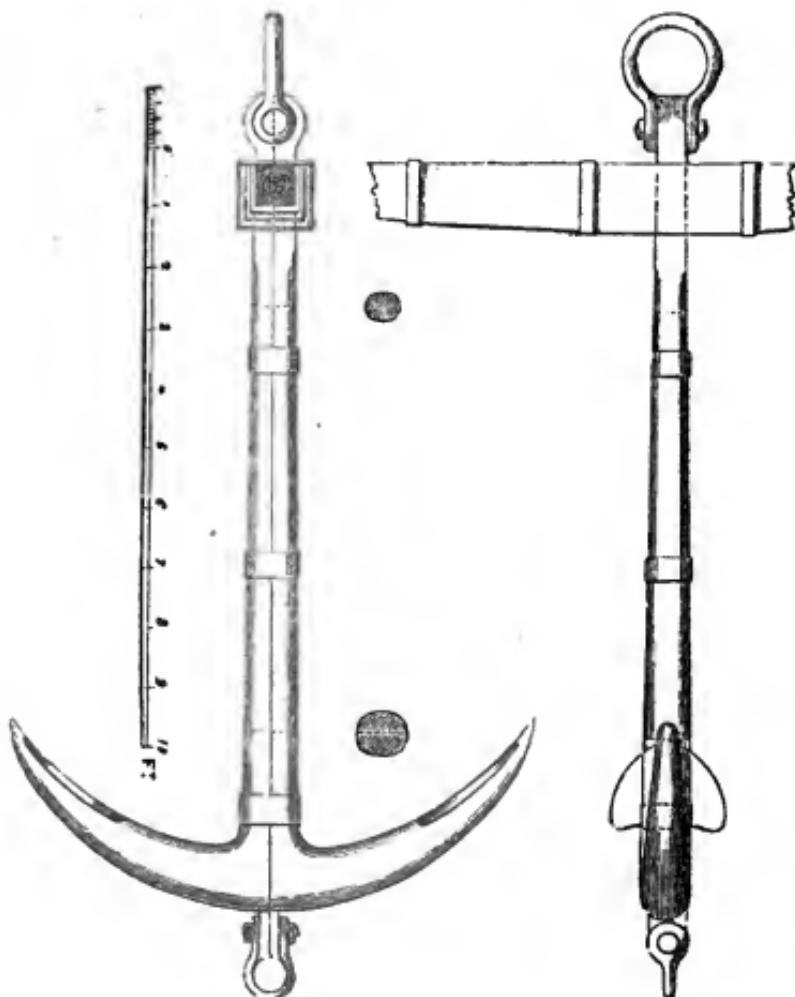


Section at *a a*.



PLATE 7.

Capt. HALL's Patent Anchor.



CAPT. HALL'S PATENT *PORTABLE* ANCHOR.

(Plate 7.)

Plate 7 is a drawing of Captain Hall's anchor: he thus speaks of its uses:—

1st. "In the event of a ship getting on shore, her launch or long-boat could carry out and let go the *two* halves separately, in weather when she could not carry out the whole anchor at all; and when the two halves are laid out with the "Bower" cables (or even the "Streams") bent to them, the two halves would hold better than if the one whole anchor had been laid out.

2nd. "Although this anchor might cost more than the common anchor in the first instance, yet in the event of a "flue" being carried away (which would render a common anchor useless), a vessel carrying a spare half with her would be enabled to shift the broken half, and replace it by the spare perfect half. The spare half could also, if required, be used as a mooring anchor, or as a "stream" to lay out on common occasions.

3rd. "Supposing a ship were to part in the Downs or any other anchorage, or to get on shore on the Goodwin Sands or any other shoal, and required an anchor from the shore, how much easier would it be to take the two halves off in separate boats from, for instance, Deal, and to get them on board, or lay them out separately, if necessary, than it would be to carry the whole anchor.

4th. "In kedging ships ahead in rivers or shoal water, the two parts of a small anchor might be used and carried out with decided advantage over the old one, both from the ease with which they might be weighed, and the facility with which they might be stowed away.

5th. "A ship mooring in rivers and other sheltered places where the water was shoal, might moor with the two halves, and thus prevent the risk of injuring herself by getting on her anchor or other vessels in passing.

6th. "Backing anchors, a half bower (if not heavy enough), or any other anchor of this description, could be backed much more easily with smaller anchors (of the same plan) than the anchors of the old construction.

7th. "This anchor presents very great facilities for stowage."

PLATE 8.

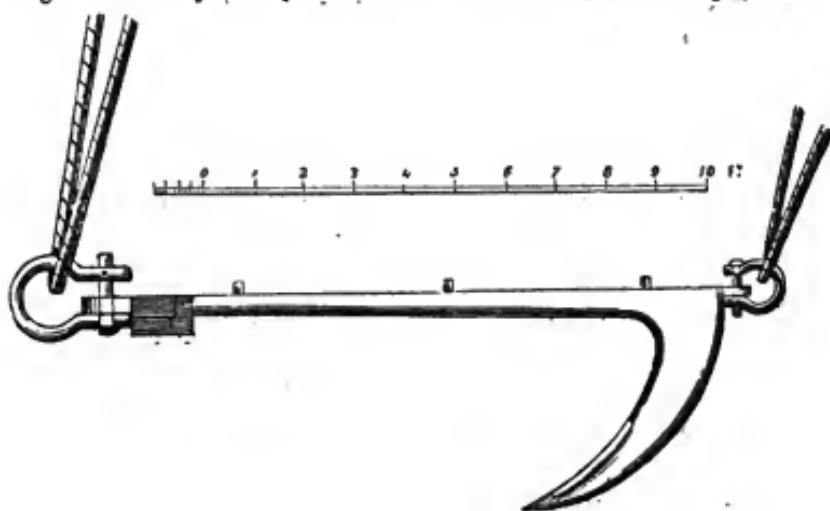
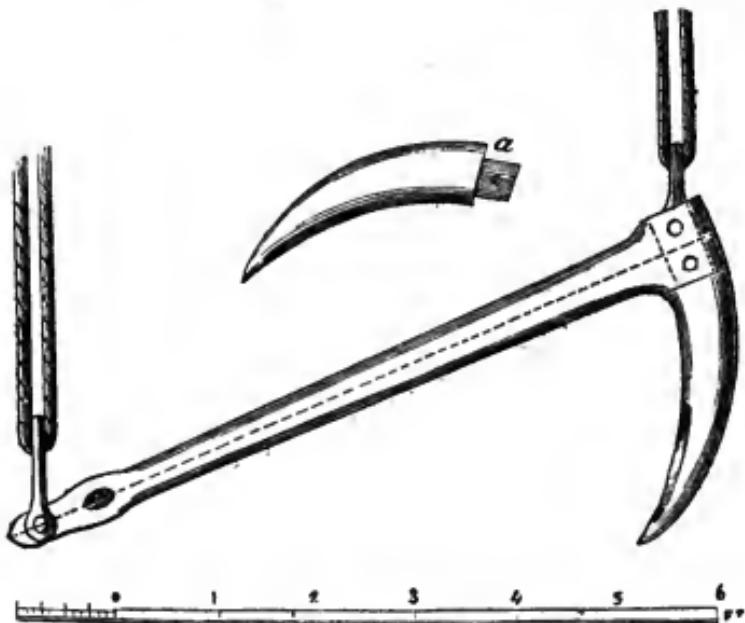
Fig. 1. The *half* of Capt. HALL's Anchor for use as a Mooring Anchor.

Fig. 2. COTSELL's Portable Anchor for use as a Mooring Anchor.



It is evident that this anchor loses greatly in strength by being separated : each half is certainly of much less strength than an anchor of an equal weight : *vide* Plate 8, fig. 1. Supposing one of these anchors to weigh 30 cwt., each half employed separately is of much less strength than an ordinary anchor of 15 cwt., for the very obvious reason, that the shank, being only *half* the size of the entire anchor, has the greater amount of material the reverse way to the strain, and is, consequently, liable to be bent at a small amount of strain ; and when bent, it cannot be again united or fitted to its fellow half until repaired.

This appearing to me to be a very serious defect, I submitted a plan for an anchor with movable arms—which, when used as a mooring anchor, with one arm detached, is equally strong, or nearly so, as when entire. The arms of this anchor are secured by means of a “pin and pellet,” in the same manner as the pins in the shackles of the chain cables.

An anchor on this plan, weighing 9 cwt. 2 qrs. 16 lbs., was made in Chatham Yard per “A. O.,” 2nd of May, 1847, and tested at Woolwich in July, 1847. See the plan of this anchor, Plate 8, fig. 2. It has been once to sea, and returned again into store at this yard uninjured ; has been since re-issued, and is at present in actual service. The strength which this kind of junction of the arms to the shank exhibited at the trial was matter of surprise to many.

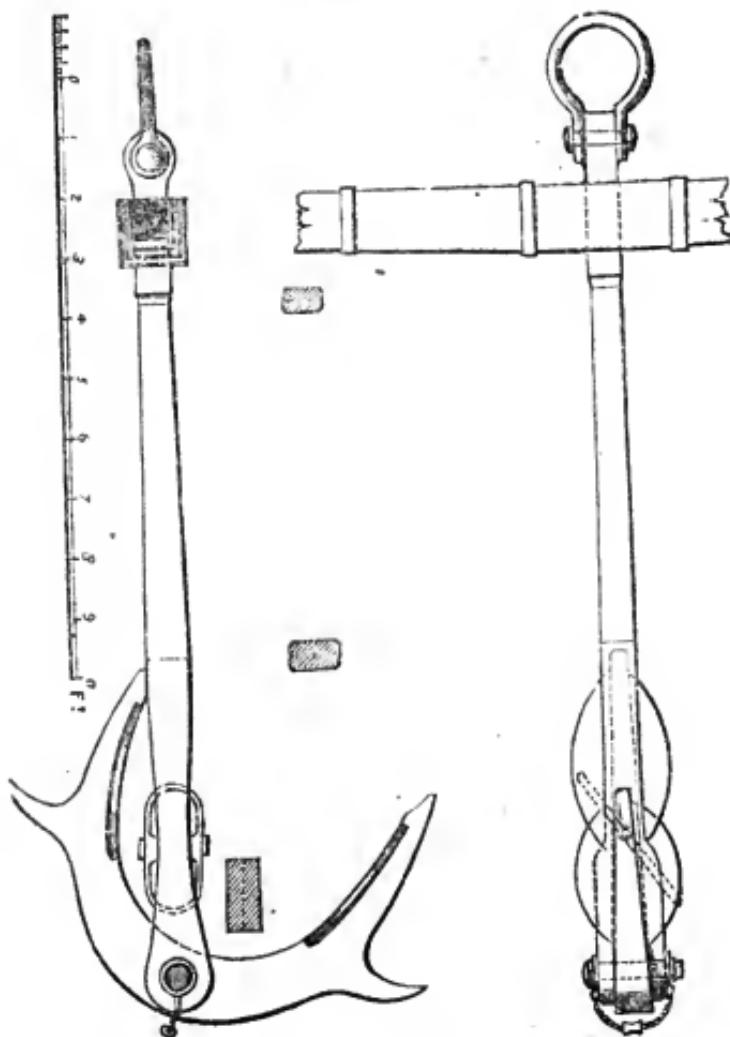
The plate represents it as about to be employed as a mooring anchor, with one arm detached ; a shackle being affixed in the socket of the crown for the head sling used in lowering it into position. The iron stock is not shown.

The weight of the anchor was 9 cwt. 2 qrs. 16 lbs. ; proof strain, 11 tons, 7 cwt. 2 qrs. It was ultimately broken at a strain of 18 tons, 17 cwt. 2 qrs., or 66 per cent. over proof. It was made to the Admiralty scale of dimensions.

The fracture took place at the tennon of the arm at the point *a*, as indicated in the drawing. The *tennon* was of the same form and size as the iron stock at its largest part : as a *rule* these dimensions for the tennon would be found to answer well. Probably at some future period this kind of junction of the arms might be improved upon. It could be formed of any reasonable amount of strength. There is no necessity for confining the crown to any particular dimensions, which, for appearance sake, was done in the instance referred to.

PLATE 9.

PORTER'S Anchor.



PORTER'S PATENT ANCHOR.

(Plate 9.)

This anchor consists of two main pieces ; the *crown* and *arms* being one, the *shank* the other—both of a rectangular form.

The oscillatory principle of the anchor is its most remarkable feature, although not entirely new.

The crown moves on a bolt in such a way that when one arm is in the ground the other is pressing hard upon the shank.

To insure its acting, horns are formed on the outer edge of the arm—without these the anchor would remain shut or closed. The upper arm would be open instead of the lower one ; as would also be the case should the horn by any means be knocked off. Instances have occurred in which the anchor failed owing to the lower arm remaining closed.

The addition of the *fish-buckle*, or loop, affixed to the shank is also a necessary appendage to this anchor. And even with this it is more difficult to "fish" than ordinary anchors.

The advantages of this kind of anchor were set forth by the patentees in a pamphlet published in 1846 ; at which period it is stated to have been most extensively used with eminent success. It had then been in use nine years—more particularly in the mercantile marine, in which anchors of "one-third less weight" had been used than the same ship would have had of the ordinary kind of anchor. It is curious to observe that the pamphlet referred to opens with a quotation from the "Nautical Magazine," of May, 1846, to the following effect :—

"The National Life Boat Society estimate, from authentic sources, that the number of British vessels yearly destroyed by shipwreck is 600 ; the value of property, about £2,500,000 sterling ; and the number of lives lost, about 1,560 !"

What chiefly concerns the public to know is, whether since the introduction of the *patent* anchors the losses by shipwreck have decreased relatively in proportion to the amount of the shipping employed ? After every storm, the papers record in

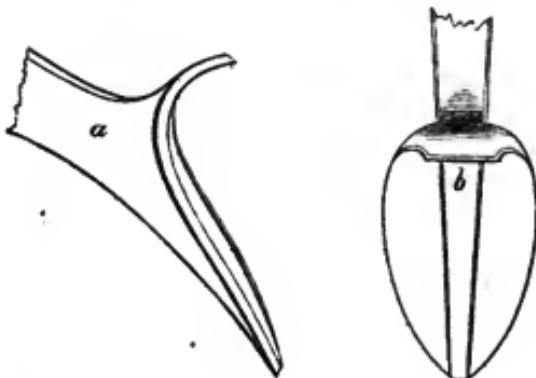
almost the same words, that some forty, fifty, or more merchant-men dragged their anchors and went to pieces on the rocks or coast. Of course, we are not told how many of them had the *patent* anchors of "one-third less weight" than the ordinary anchors. This kind of economy in so important a matter is highly reprehensible and dangerous.

This anchor subsequently to 1846 passed into the hands of Honiball, and still more recently into the possession of Mr. Trotman, who has introduced some modifications of the horn and palm—as far as we know, with some advantage to the working of the anchor.

The opinions of naval officers and others respecting the working of this (Porter's) anchor, have been very conflicting. Recent reports from the Mediterranean, from Admiral Dundas, I believe, have induced their lordships to propose to reconvert them.

The alterations made by Trotman may be stated briefly to consist in uniting the horn and palm; which has been effected by forming the palm in the centre of the *blade*, instead of the *fore-side* of it, and continuing the palm outwards *beyond* the blade so as to form the *horn*: by this means the latter is made to present more surface to open the anchor than did those of Porter's patent—at least, such would appear to be the object of the alterations, and the continuation of the *palm* downwards to the extremity of the "blade." This causes the palm to partake of the *Dutch* palm; more or less adopted by Mitchellson, Lenox, and Aylen; Rodger having previously adopted it. See my Letter, February, 1848.

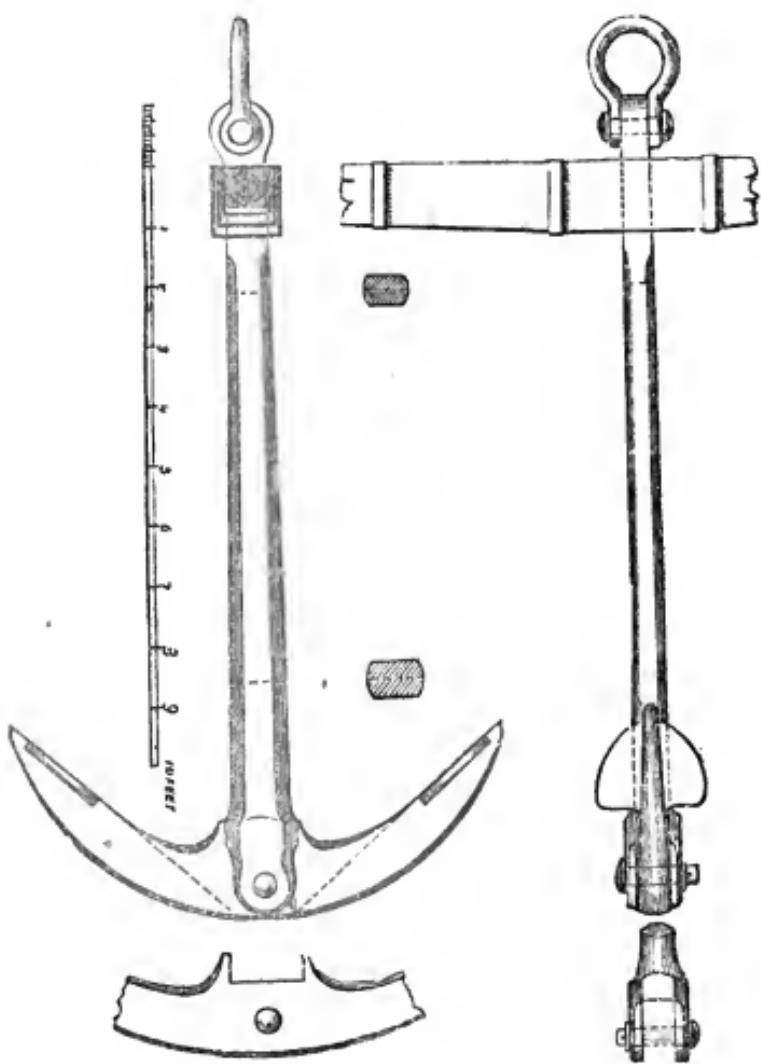
The following sketches, *a*, *b*, show the alterations of the "palm" and "horn" referred to, and which distinguish this anchor from the original or Porter's anchor:—



Practically this alteration involves much difficulty to the workmen; and although the anchor tried at Sheerness was well made, the weight 21 cwt. only, (and made specially for that trial,) it affords but little opportunity to judge of the character of the alteration when applied to the largest anchors; and when the ordinary course of business shall have become the order of the day—it being too well known that much less care will follow when the occasion for display has passed away.

PLATE 10.

COTSELL's improved Portable Anchor.



COTSELL'S IMPROVED PORTABLE ANCHOR.

(Plate 10.)

The following letter was submitted on the subject of this anchor, with some general remarks on other anchors, which it is desirable to place on record :—

[COPY.]

*"Chatham Yard,
" 16th February, 1848.*

“SIR,

“ I have the honour to submit, for the approval of my Lords Commissioners of the Admiralty, the model of a Portable Anchor, plans for which, through your kindness, I had the honour of laying before the Secretary of the Admiralty, and, through the kindness of the latter gentleman, before Lord John Hay, C.B., on Tuesday the 8th inst.: the reception the plans then met with was highly flattering.

“ The advantages of a portable anchor over that of a solid one are many; but to me it appears that the chief one is the facilities afforded in being enabled to apply one uninjured part of an anchor to that of another anchor; namely, the crown and arms of one anchor to the shank of another, which is in effect as though one or two additional anchors were issued to each ship. I speak of Bower anchors only.

“ It is an important fact, that when a solid anchor is injured it becomes *wholly* useless, the portable one only *partly* so.

“ The principle of double clamping, by which the shank and crown are united, is very simple, and insures great strength, and cannot fail, if adopted, to be eminently useful, and may be cheaply manufactured; nearly equal to three-fourths of the whole may be wrought under the steam hammer.

“ In the plan now submitted, the parts become completely locked in the direction of the strain without the aid of the bolt, the latter being affected only when the strain upon the anchor is excessive; and then, as may be seen by the model, each part partakes of it equally.

“ The statements of Lieut. Rodger, and of Porter & Co., relative to the superiority of their anchors over those of the Admiralty plan, in bringing the ship up more readily, and holding her more securely, have induced me to investigate the matter;

PLATE 11.

Fig. 1. Sketch of part of Admiralty Anchor.

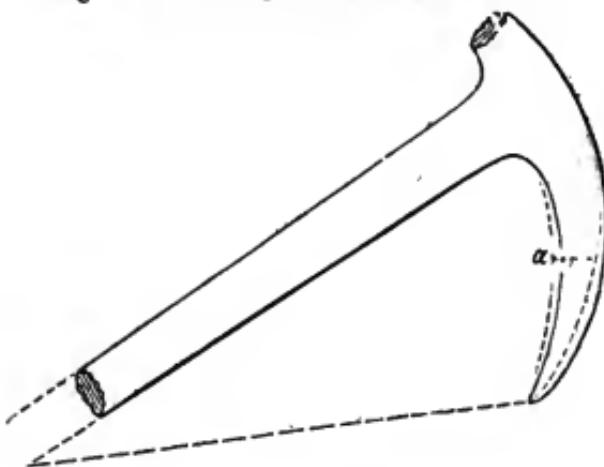
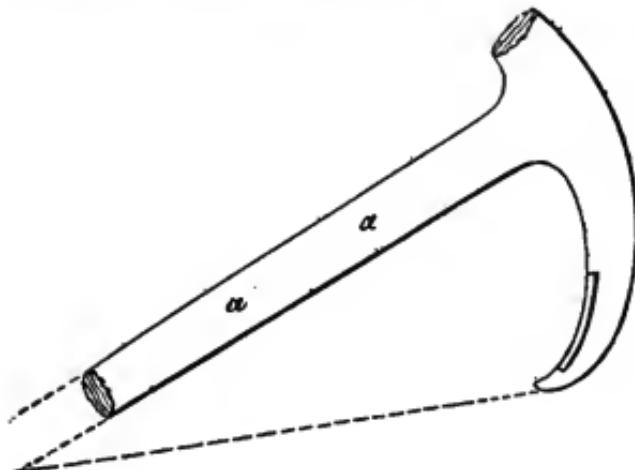


Fig. 2. Sketch of a Fish Hook.



Fig. 3. Arm badly curved, destructive of nipping and holding properties.



and although these statements may admit of great qualification, the superior quality spoken of may nevertheless be accounted for by the fact, that the arms of their anchors are longer, and the shanks generally shorter, than those of the Admiralty anchor; and, consequently, the arms are at a greater angle from the shank. I submit a statement of dimensions of a few of these anchors now in store at this yard, to show the disparity of the *patent* anchors to those of the Admiralty plan. It is difficult to say upon what principle the relative length of arms and shank of these anchors is regulated.

Makers.	Weight in Cwts.	Length of Shank. Ft. Ins.	Length of Arm. Ft. Ins.
Rodger . . .	54 . . .	13 1½ . . .	5 0 }
Admiralty . . .	54 . . .	13 11 . . .	4 7½ }
Porter . . .	53 . . .	12 8 . . .	5 0 }
Admiralty . . .	53 . . .	13 10 . . .	4 7½ }
Porter . . .	26 . . .	10 8 . . .	4 0 }
Admiralty . . .	26 . . .	11 0 . . .	3 8 }

"A sketch of part of an Admiralty anchor is forwarded herewith, showing the alteration I would propose to make in the disposition of the palm (*vide* dotted lines), and which is adopted in the model now submitted, with a view to improve the nipping and holding qualities of the anchor. This alteration, although slight in appearance, is calculated to be highly beneficial. The outer curve of the arm is scarcely affected; the inner curve is similar as far as the heel of the palm at *a*, after which it exhibits a straight line to the point of the arm at *b* in red.

"The sketch of a fish-hook, in which the barb (or spear) is invariably set straight, will serve to illustrate the principle by which I have been influenced in altering the disposition of the 'palm' of the anchor. The *nipping* property of the fish-hook is proverbial.

"The curved arm exhibits great beauty, and is much stronger than the straight arm; still, the question of curvature is one of degree. Want of care in the workmen, by giving an undue proportion of curve in the 'palm,' will destroy the efficiency of the anchor—an error too often committed in contract anchors. The sketch *a a* shows that these irregularities prevent the anchor from nipping readily, and have besides more or less tendency to cause it to forsake its hold according to the angle which the shank presents to the ship's bows.

"The immense amount of property, and the number of valuable lives, frequently depending for safety solely on the efficiency of the anchor, and the cost of the anchor itself, will, I trust, be a sufficient apology for the length to which these remarks are extended. The subject is too large to be dealt with summarily.

"I respectfully request you will be pleased, in transmitting the model, &c., to the Board of Admiralty, to move their Lordships to allow an anchor of about 40 cwt. to be made on the plan now proposed; and, when made, to be tested in every possible way.

"I have the honour to be, &c.,

"GEORGE COTSELL.

"Captain Sir Thomas Bourchier, C.B.,

"Superintendent, &c., &c.,

"H. M. Dock-yard, Chatham."

On the 23rd February, 1848, I had the honour of receiving their Lordships' commands to make an anchor on this principle of about 40 cwt. In obedience to which, one of 39 cwt. 2 qrs. was completed in April, tested at Woolwich Yard, and issued to H. M. S. Cleopatra in May, 1849, Thomas L. Massie, Esq., Captain; my Lords Commissioners having directed that the anchor was to be the *working* anchor; thus showing that its merits were to be fully tested.

A prospectus published in 1848, respecting this Anchor, is repeated here, in order that the statement may stand the test of investigation, should any one be disposed to canvass its merits.

"Its principal dimensions are the same as the Admiralty anchor; the shank and arms are flattened to give more strength in the line of the strain, and the *inner* surfaces of the 'palms' are kept straight to the proper angle, which will cause the anchor to *nip* the ground readily, and to hold firmly when once inserted.

"For the purpose of weighing or tripping the anchor, the external curvature of the arms is preserved.

"It is very simple and strong, may be cheaply made, and easily repaired; can be 'fished' 'catted,' &c., with facility; and possesses all the properties of the ordinary anchor, with the advantages of portability.

"It is presumed, from the construction of this anchor, that under excessive strains it will be less liable to be

broken at the *crutch* than the ordinary anchor. The angle of divergence may be somewhat increased, and still its *holding* properties remain unimpaired.

"There is no *actual* 'deflection' in this anchor until the strain becomes very great."

Nearly eighteen months after, Captain Massie wrote from "Trincomalee," under date 3rd September, 1850:—

"H. M. S. Cleopatra.

"SIR,

"Your anchor having been in use in this ship upwards of one twelve-month, I think it is only fair to give you some intimation as to how it has answered.

"As an anchor it has done its work well, and held the ship in all weathers, though I am happy to say that as yet we have not had an opportunity of testing it in a typhoon.

"We have generally used it as our working anchor, and have frequently let it go in very deep water, from twenty-eight to thirty fathoms, and it has shown no signs of weakness.

* * * * "The anchor is still in use as one of our bowers; and I have no reason to suppose it is not as strong, and as much to be trusted to, as any other of our anchors."

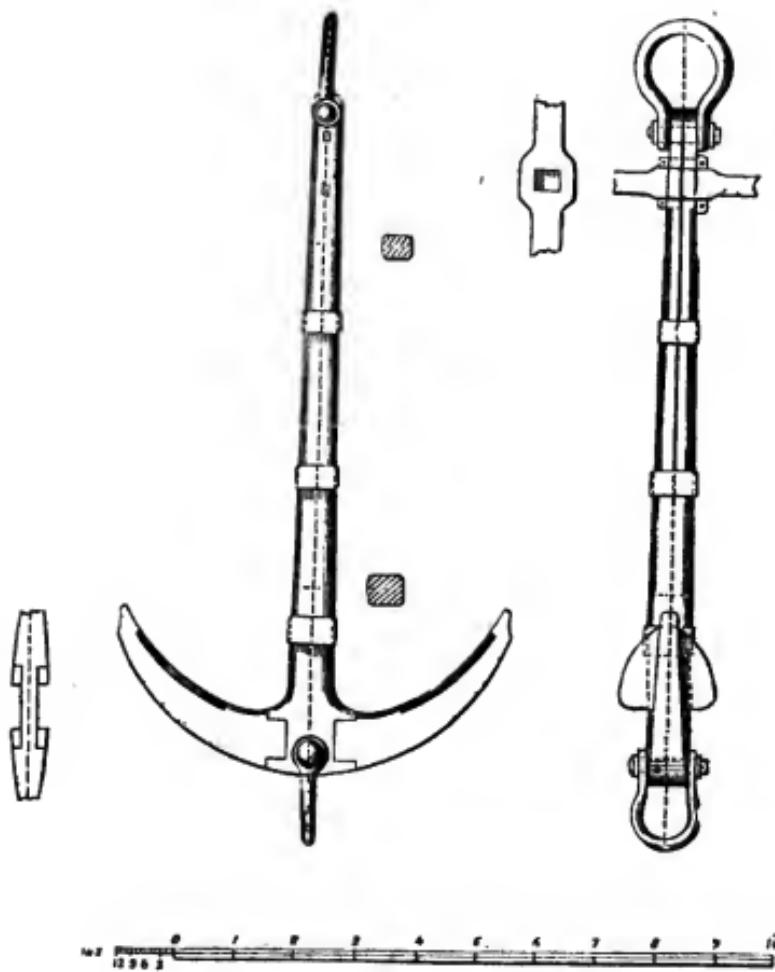
Captain Massie stated that they had tried to get the bolt out, but could only start it two inches; the fact being, that from circumstances which I have no wish to recapitulate I was forced into a mode and nicety of "fitting" of this anchor not consonant with my original intentions, and not at all necessary to the efficient working of a *portable* anchor.

After four years and a half *constant* employment of this anchor in the India and China seas, it is returned into Chatham Yard; a report is made to the Board of Admiralty by Captain Massie, which is an echo of his statements just referred to. The anchor being subsequently brought to the smithery, the bolt is got out, cleaned, and tinned; and the anchor, on the most careful examination, is found to be in every respect as when shipped to the Cleopatra—not the slightest alteration of any of its original lines, and the bolt of

PLATE 12.

HUTCHENS' Portable Anchor.

(Iron Stock.) 21 cwt.



the crown not in the least strained. The only reason for the bolt not coming out is, that it was perfectly parallel and closely fitted, and the rust when the bolt was driven back rolled up and set fast, so that it could not go further. In practice, it is often found necessary in other articles, such as Capstan Gear, much subject to rust, to drive the pin or bolt first back, then home again, several times; by these means the rust gets pulverized, falls out, and the pin will shortly be relieved. This hint may be useful to nautical men whose means for such purposes are often limited on board ship. As explained to Captain Massie when this anchor was supplied to the Cleopatra, the pin should be taken out once every three months, and very little rust could take place in that period. "Tinning" the pin, and tapering it one-fourth of an inch in its whole length, will most effectually obviate all the difficulty.

It has been held by naval officers of high standing, to be a "desideratum" in the navy to have an efficient *portable* anchor; if so, then it may not be asking too much of naval officers to assist in rendering them *portable* by a periodical inspection of such anchors. In an article so liable to corrosion an overhaul once every three months would prevent the adhesion of the parts, which, if long neglected, must necessarily ensue.

HUTCHENS' PORTABLE ANCHOR.

(Plate 12.)

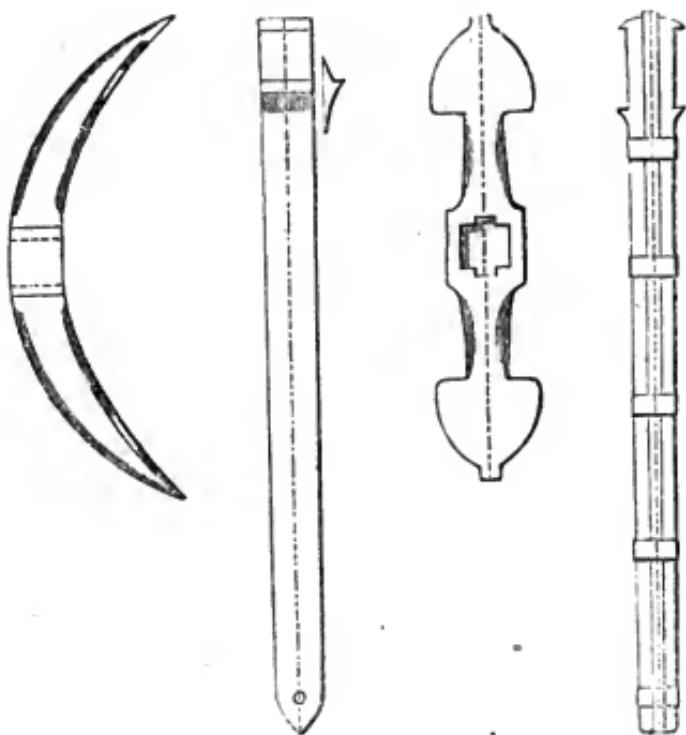
This anchor was made by the inventor, Mr. John Hutchens, late of Portsmouth Dock-yard.

It consists of three main pieces—the crown and arms being one—and the shank, *two* pieces. The latter embrace the crown by a kind of dovetailing, somewhat resembling a T; a seating being formed in the crown to receive it. Three hoops, and the bolts of the shackles, of which there are *two*, one at each extremity, hold the shank firmly together.

An anchor on this plan was made in Portsmouth Yard about the year 1846 (weighing 28 cwt.), and was issued to the Rattlesnake, for, as might be presumed, an experimental trial at sea. There does not appear to have been any trial

PLATE 13.

Sketch of MORGAN AND LITTLE'S Portable Anchor.



made of this anchor. I was informed that it had never been out of the hold of the vessel. The inventor had died in the interim of its being on board the Rattlesnake ; he was, consequently, spared the mortification of knowing the slight to which his invention had been subjected.

The principal dimensions of this anchor were according to the Admiralty scale. There can be little doubt of its strength. The shank requiring to be hooped together is objectionable, and can scarcely be favourably viewed by naval men in general.

This anchor is now in store in Chatham Yard : as will be seen by the plan, it has been fitted with Rodger's stock. The only object of the inventor would appear to have been to supply a *portable* anchor, and not to introduce any other improvement.

MORGAN AND LITTLE'S PORTABLE ANCHOR.

(Plate 13.)

This anchor consists of eleven pieces :

The crown and arms being *one* piece ; the shank, three pieces—with two throat pieces and four hoops ; the shackle, one piece.

The crown was formed with a mortice, through which the shank was inserted from the outer side ; the middle piece forming a wedge to set the other two pieces home ; and the bolt of the shackle, together with the four hoops, secured all together and kept the parts in place.

An anchor on this plan, of 37 cwt. was made in Portsmouth Yard about the year 1832 ; length of shank, 11ft. 8 $\frac{1}{2}$ ins. ; arms, 4ft. $\frac{1}{2}$ in.

It is recorded that the time occupied in putting this anchor together, and fixing the stock to it, was fifteen minutes ; taking it to pieces again, five minutes.

It will be obvious to any practical man, that such an anchor must be strong ; and equally so that it must be expensive to manufacture ; for the number of pieces or parts will occasion much labour and skill in fitting, and if once strained it can scarcely be put together or separated.

I am not aware what became of it after it left the Dock-yard.

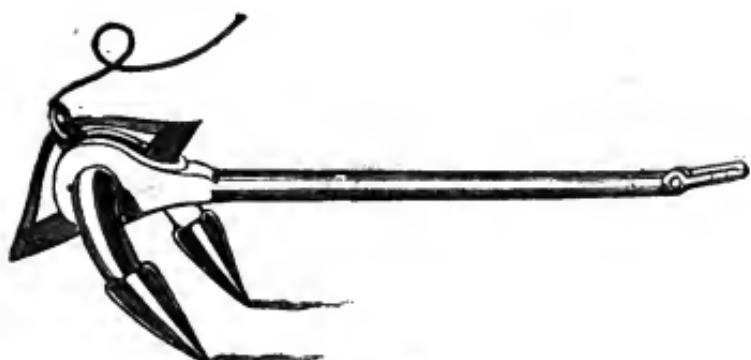
PLATE 14.

R. F. HAWKINS's Patent Anchor.



With Toggle out.

Toggle.



Holding position.

HAWKINS'S PATENT ANCHOR.

(Plate 14.)

Many other attempts, at various times within the last fifty years, have been made to improve the anchor, and others again to supply anchors of a totally new character; as, for instance, the Patent Anchor of Hawkins's construction; requiring *no stock*; both palms acting at the same time; with a tumbler acting crown; but not portable. See Plate 14.

The patentee remarks—"Its advantages are many, and all arise from the anchor being so constructed that *both the flukes* (which act on a revolving principle) penetrate into the ground at the same time. The consequences are,

"First. That it therefore holds nearly equal to *two* anchors.

"Secondly. That it will *not foul* or cut, chafe or injure the cable.

"Thirdly. That it does not require a stock.

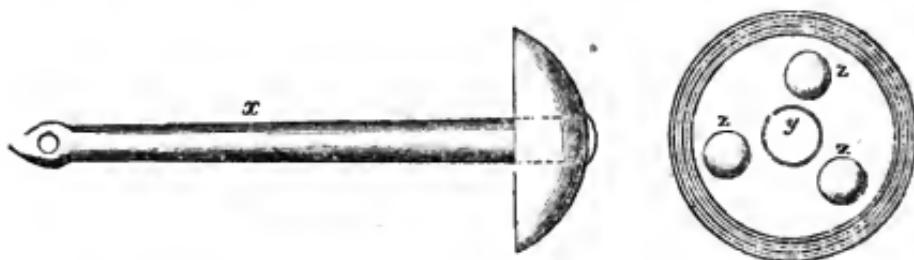
"Fourthly. That it breaks ground much easier, and is more conveniently worked; does not impede the way of the vessel in being hove up; will stow without any projection; can never injure the bows in weighing, catting, or fishing; and is particularly well *adapted for kedging*.—And,

"Fifthly. That in the event of a ship grounding upon her anchor her bottom cannot be injured, which is often the case with the common anchor."

It would appear that this anchor was not extensively patronised, and has altogether fallen into disuse.

Another effort was that of the late Mr. Kingston, Engineer, of Portsmouth Yard. A *metal* anchor, cast with a hollow or cylindrical shank, the cable passing through the entire length of the shank. The opening at the crown of the anchor was trumpet-like, which received the knot or clench of the cable. No alteration was proposed by him in the general dimensions of the anchor. One of these anchors remained in store at Chatham Yard for many years, but has been broken up and reconverted.

Then, again, we had what was denominated the "Parachute" (some called it the "Mushroom") anchor. This, like the one by Hawkins, required no stock. Its holding power could scarcely equal the ordinary anchor; whilst the trouble of forging the crown was immense, and in heavy anchors, say of four or five tons, beyond all calculation. The name of the inventor is not known to me. One on this plan was made in Portsmouth Dock-yard, but the report of the officers was probably unfavourable. Neither nautically nor mechanically were its advantages such as to recommend it. (See Sketches *x* and *y*.)



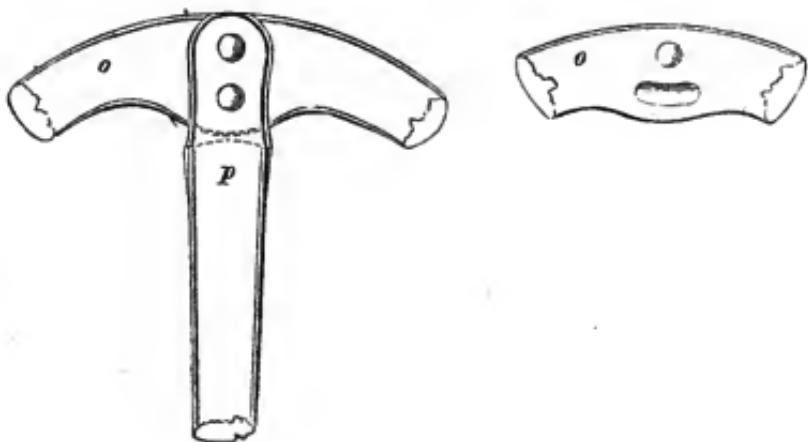
The shank was formed with a collar, and passed into the crown, being clenched on the outside. *z z z* are openings to admit of the mud or other matter which necessarily came up with the anchor being got rid of.

There is nothing but the absence of the stock to recommend this anchor. As an anchor it falls short of the essentials necessary to success.

There is also the Patent Anchor of Captain Dwyer.

This is a portable anchor partaking somewhat of the principle of Porter's. The shank is similar. There are *two* bolts in the crown, instead of one; one over or above the other, in the line of the shank. The crown moves on the upper or outer bolt, and is stopped by the inner to the angle at which the patentee determines the arm to act. Hence it is partially oscillating, but less so than Porter's; and the second or inner bolt serves, apparently, the office of the *horns* on Porter's anchor. The palms are somewhat singularly formed, the points being set back to assist to bring the crown to its bearing upon the inner bolt. The strain is consequently on the bolts.

See Sketch *o p*, from which it will be seen that the crown is made to traverse partially past the inner bolt—the upper arm, when the anchor has hold, being at a less angle from the shank than the lower one, according to whichever arm happens to be brought into play. One of these anchors, manufactured by Hawks, was lately to be seen in Woolwich Yard.



The inventions and suggestions of which the author has no means of doing more than to make honourable mention are many, and some others are altogether unknown to him. Amongst the former might be placed—

That of Hawks, a plan which consisted of inserting the "stock" through the crown of the anchor, with stays or spurs, coming from the end of the stock, keyed to the shank—not an original idea, as the Chinese put the *stock* through the crown of their anchors ages ago.

That of Lieut. Inglefield, which might be regarded as partly portable; partially revolving, or movable, in the crown; which latter is of a very peculiar form, and, like the Mushroom anchor, already referred to, very difficult to make. A model of this anchor was in the Great Exhibition of 1851, in Hyde Park.

That of Mr. Miller, late of Devonport Dock-yard. The plan was to form the crown with a hole to receive the shank; the hole being round, the shank was formed with a collar, which gave a *throating* to the inside of the crown when the shank was clenched or shrunk on. The object seemed to be to avoid "shutting" on the

arms. An experiment was made at the Dock-yard at Devonport, of this plan, which was said to have been unsuccessful.

Some other inventions have not advanced beyond the first stage: namely, they have been merely exhibited in *models*. Of this class there are many. Only a very few of them have come under my own observation.

One model, that of Mr. William Smale's invention, having seen, I would briefly observe, that it is a portable anchor, composed of several pieces. The stock passes through the crown. It is generally of the Admiralty dimensions. The reason for transferring the stock to the crown, instead of fixing it to the square of the anchor, I cannot divine. It being more liable to injury in such a position, involves the liability of the loss of the crown and arms of the anchor. I presume that in a portable anchor, more especially than even in an ordinary one, the position of the stock, and its greater liability to injury, must prove fatal to the invention or design. A model of this was in the Great Exhibition of 1851.

Amongst those who have devoted their attention to this subject, and made suggestions which have been either partially or wholly carried out, or remain in abeyance, and which relate chiefly to the mode of forming the parts at the forge, and the "scarfing" and bringing the parts together, are—

Mr. FINCHAM,
,, SMITH,
,, NASMYTH,
,, TYLER,
,, TRUSCOTT,
,, BLAKE,
and others;

showing that, both *theoretically* and *practically*, the subject has been kept constantly open to discussion; and it would be ungenerous to suppose that the anchor has not been improved under the circumstances; but it might be safely affirmed that a very great improvement has taken place, to the benefit of the public service.

. The statements respecting some of the inventions last referred to, are, from the absence of drawings or models, necessarily imperfect; and in treating of them chiefly from memory, it is probable I have not done the inventions that justice I would have done had drawings or models been open to me to consult. But I felt it necessary to refer to them, rather than incur the charge of having omitted them.

A TREATISE ON SHIPS' ANCHORS.

PART II.

THE APPOINTMENT, CONSTITUTION, AND REPORT OF THE COMMITTEE OF 1852, CONSIDERED.

The Committee of 1852, in their Report, page 9, paragraph 27, are pleased to say—

"They have deemed it of so much importance, that every opportunity should be given to those interested in the efficiency of anchors to form their own conclusions, if not satisfied with those of the Committee, which, in so intricate a question, can lay no claim to mathematical precision, although for the reasons before stated expressed numerically, that they have decided in giving publicity in the following tables to the successive steps by which the final results have been attained; so that if, in the opinion of others, any of them are founded on wrong bases, the means may be available to modify the conclusions arrived at by the Committee, who consider it to be of far greater importance that all legitimate discussion should be courted and encouraged, than that the means of forming individual judgments should be sacrificed to an apparent completeness and symmetry in their Report, which would, perhaps, have been gained had they confined themselves, as they might have done, to categorically expressing their opinions on the relative collective merits of the anchors, irrespective of their distinctive properties."

And further, at page 11, paragraph 33, they say—

"And the Committee would suggest that further trials may at some future period be undertaken to ascertain whether such an alteration, which the accompanying wooden models will serve to explain, would be productive of the improvement in the holding properties of the Admiralty anchor which their own observation of its actual working in the ground leads them to anticipate; and should their Lordships think proper to adopt this latter suggestion, the trials might take place on the beach at a comparatively small cost, as the capstan used at the late trials, and the old anchors to which the standing parts of the purchases were made fast, might remain there until required for the purpose."

I accept, with cheerfulness, the invitation to discuss this subject, which the Committee are pleased to throw out; the

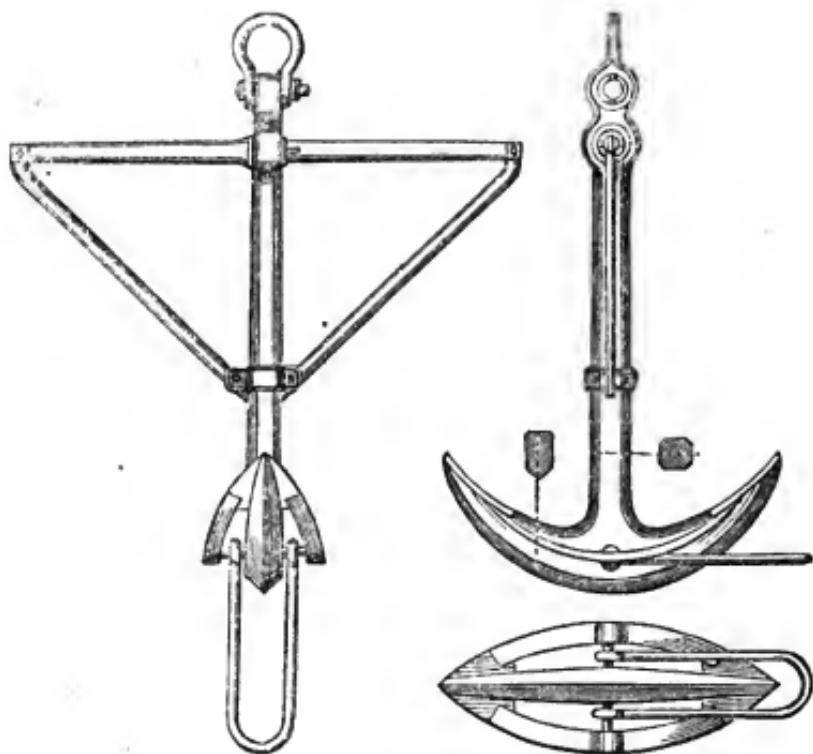
more so, that the prospect of another opportunity for *testing* the properties of the Admiralty anchor, modified according to certain suggestions of the Committee, are likely to take place at some future period.

I trust that the suggestions of the Committee may be carried into effect, and that the field of honourable competition may be thrown open to all those whose business must render them concerned for the interests of the two services, and that none may be excluded from participating in the settlement of this great question. I have said, for the *interests* of the *two services*—the *interests of humanity* would probably be more to the point.

Sketches of the anchors tried at Sheerness in 1852, as published in the *Report* of that Committee, are inserted in this place, for the purpose of keeping up a faithful record of the several efforts made at that time to furnish an efficient anchor; and, with the illustrations before him, the reader will be enabled to understand upon what grounds I have been induced to discuss the “*Report of the Committee*,” chiefly with reference to the anchors on the plans of the Admiralty, Rodger, and Trotman.

PLATE 15.

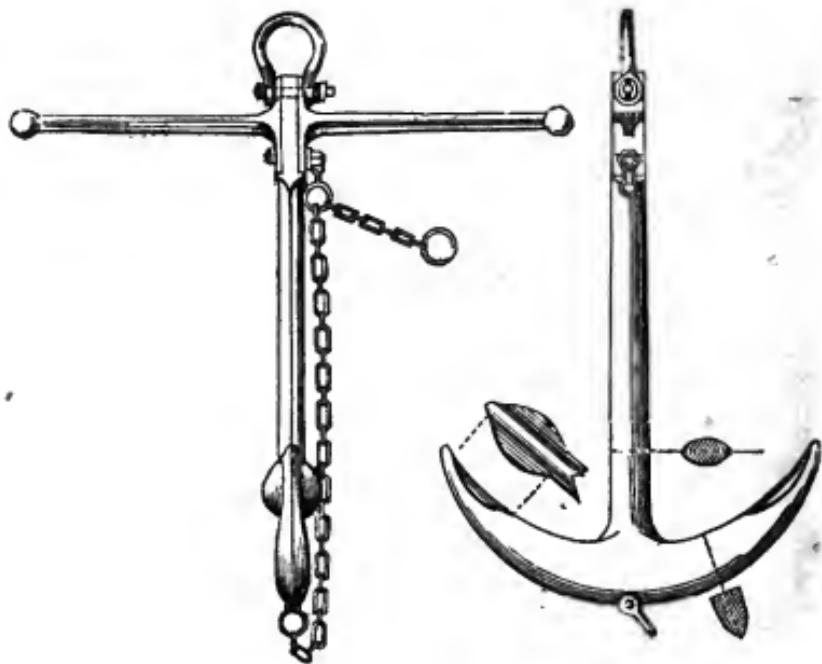
ISAAC's, United States.



	Cwt.	qrs.	lbs.
Weight of Anchor	21	0	14
" Stock	4	0	3
Total . . .	25	0	17

PLATE 16,

MITCHESON'S,

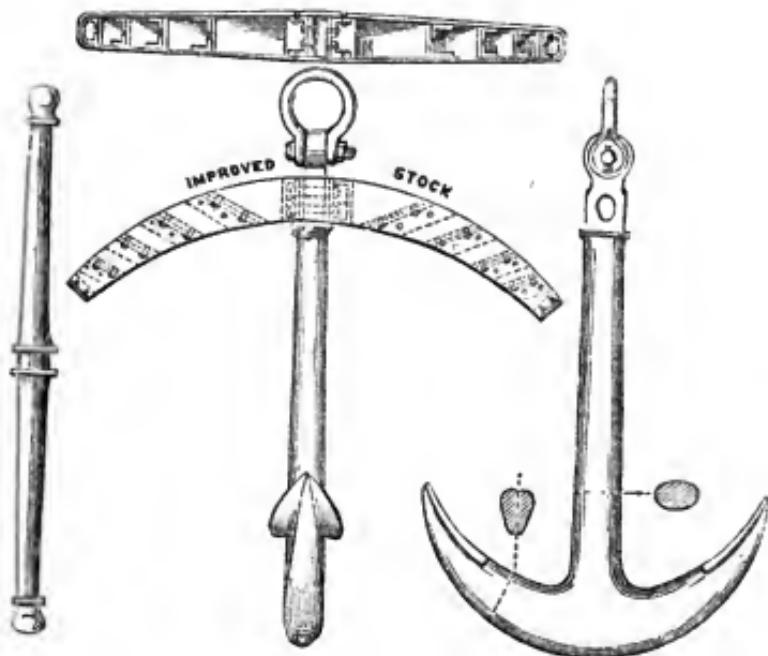


	Cwt.	qrs.	lbs.
Weight of Anchor	2	10	0
,, Stock	4	0	14
Total	25	0	14

PLATE 17.

LENOX'S.

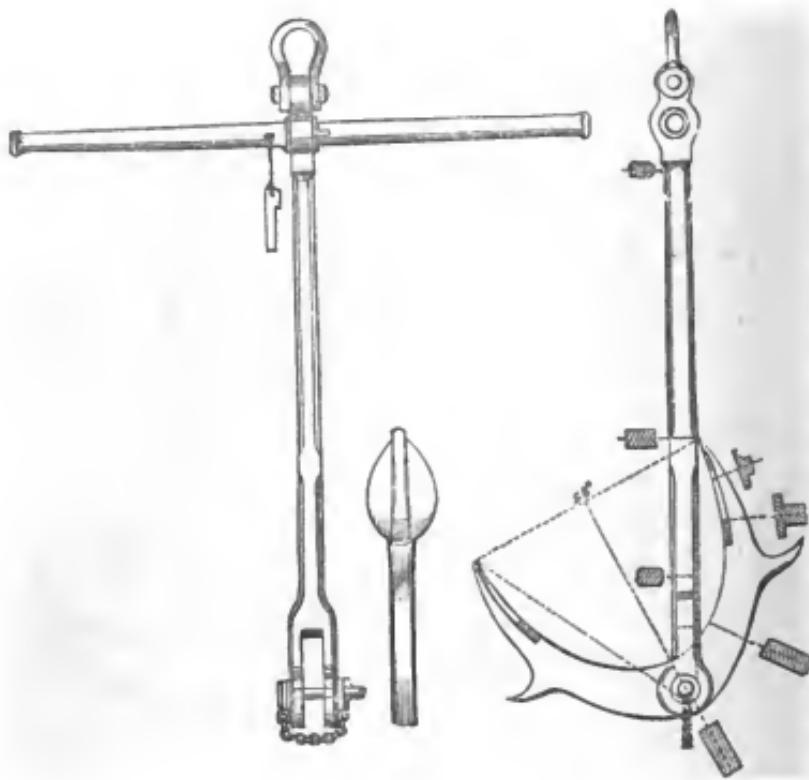
IMPROVED STOCK.



	Cwt.	qrs.	lbs.
Weight of Anchor	.	.	20 3 14
" " Stock .	.	.	3 2 24
Total	.	.	24 2 10

PLATE 18.

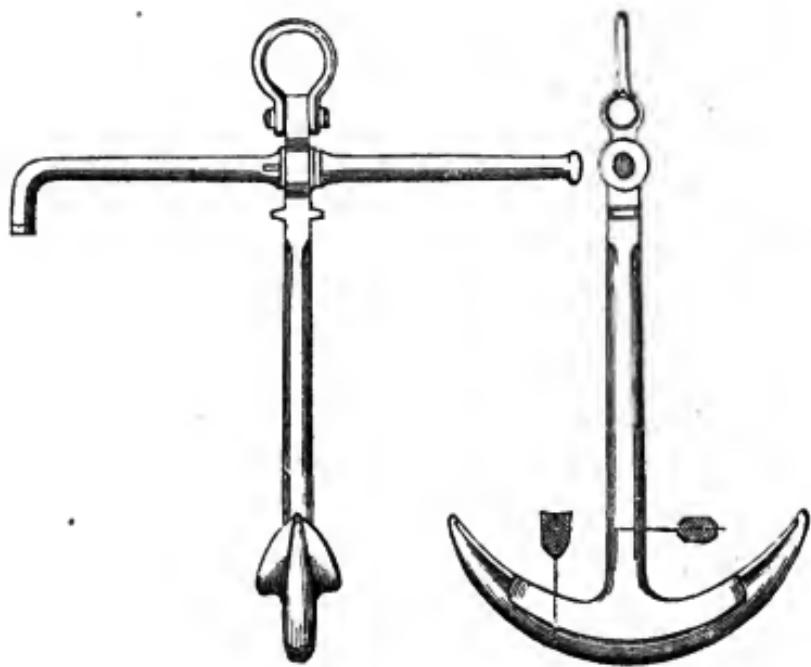
HONIBALL'S OR PORTER'S.



	Cwt.	qrs.	lbs.
Weight of Anchor	.	20	3
" " Stock .	.	3	2
Total	.	24	1
			7

PLATE 19.

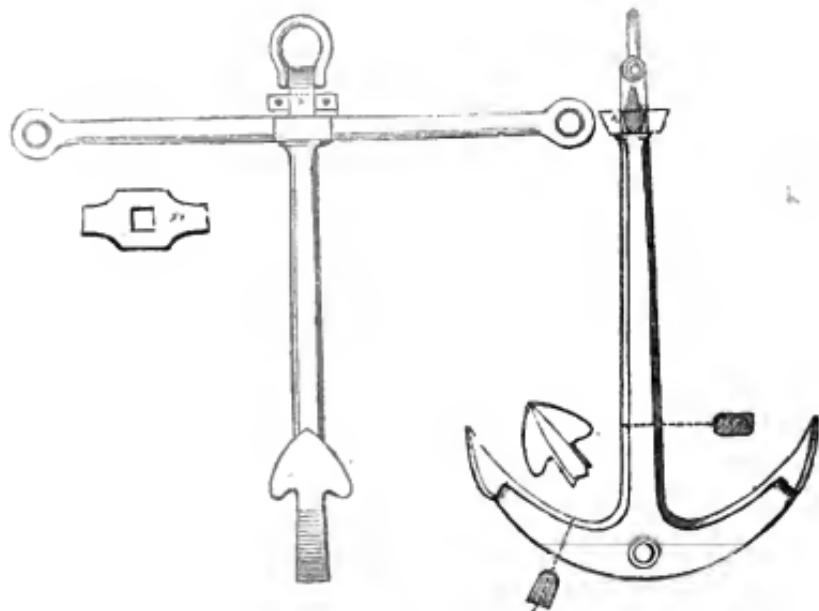
AYLEN'S.



	Cwt.	qrs.	Ibs.
Weight of Anchor	21	1	0
" " Stock	3	3	13
Total	25	0	13

PLATE 20.

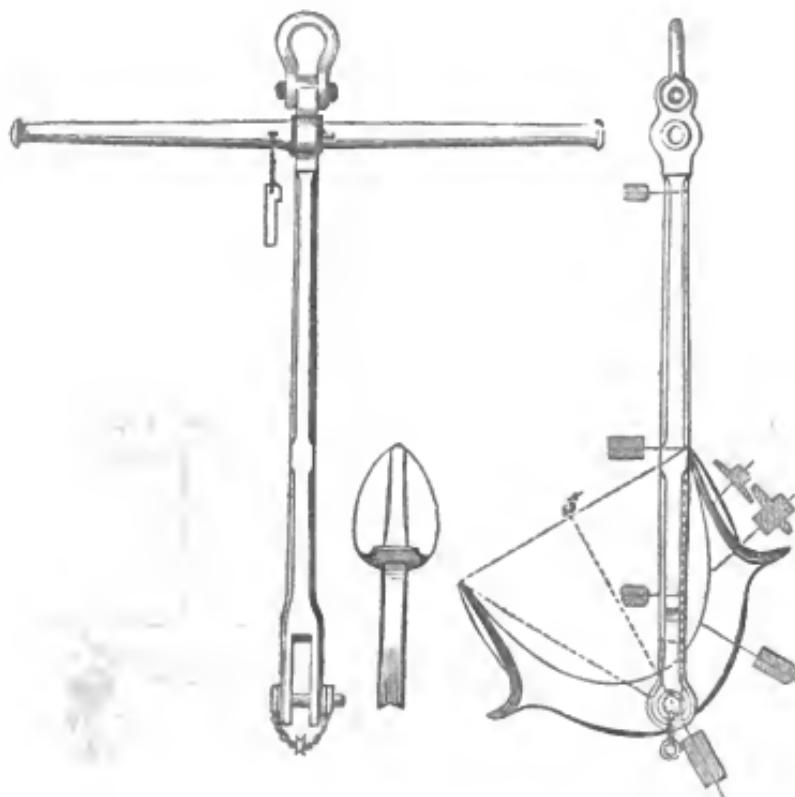
RODGER's (Bower).



	Cwt.	qrs.	lbs.
Weight of Anchor	19	0	8
" " Stock	5	2	14
Total	24	2	2

PLATE 21.

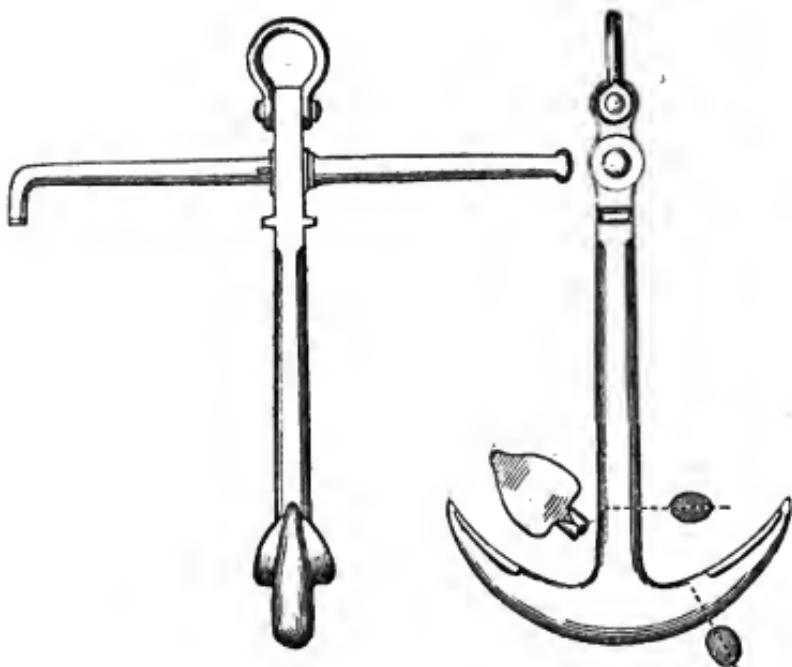
TRAUTMAN'S (Improved PORTER'S).



	Cwt.	qrs.	lbs.
Weight of Anchor	21	1	10
" " Stock	3	2	24
Total	25	0	6

PLATE 22.

ADMIRALTY.



	Cwt.	qrs.	lbs.
Weight of Anchor	20	2	6
, , Stock	4	0	3
Total	24	2	9

THE APPOINTMENT, CONSTITUTION, ETC.

I confess to a disappointment on reading the Report of the Committee of 1852—a disappointment shared by many, on the ground that nothing is settled. The whole question seems to be referred back again, as open as ever, to the Admiralty Board.

The unlimited powers given to that Committee, and the very ample means and appliances at their command, seem to warrant the expectation that this much-vexed question would have been set at rest.

The object of the Board in granting the Committee must have been to afford it the means for discussing and determining those points to which public attention had for a long period, and by various means, been specially directed—points on which few persons are capable of forming a just conclusion, when unassisted by drawings or other mechanical data.

The Board had also been frequently most unjustly aspersed with reference to certain imputed failures and fractures in the Admiralty anchor. And looking well to the circumstances which had given rise to the appointment of the Committee in question, it was most desirable that the Report of the Committee should have embraced and settled those points so frequently forced upon the attention of the public. This has not been accomplished. It had been the common practice for several years (of interested parties) to keep up a sort of newspaper warfare against the Admiralty anchor. The importance of the labours of the Committee of 1852, and the question submitted for their decision, will be best understood by reprinting at this place one of those attacks to which I have referred, directed, as will be seen, not only against the anchor, but still more so against the Board of Admiralty itself.

"Morning Chronicle," 31st March, 1848.

"The serious accident to her Majesty's ship *Queen*, the largest, and by many considered the finest, three-decker in the British navy, has been a general topic in naval circles. Such, it appears, was her perilous position, that but for the mere chance of a powerful steamer being ready at hand to drag her off the ground, there she must have remained a helpless wreck.

"By a fortuitous circumstance she is happily again afloat, though not without serious damage and loss of stores, doubtless of many thousand pounds value, necessarily thrown overboard to lighten her. Many are the

complaints, loud and deep, that have been addressed to us from all quarters of the utter inefficiency of the established anchor, or the one known as the Admiralty, or Sir William Parker's plan, both in regard to holding power and strength; for it is remembered by many that her Majesty's ship *Queen*, when at Spithead in 1842, looking about for a berth, that her anchors on that occasion failed to hold her.

"Unfortunately for the service, this worthless and expensive anchor has been christened after a distinguished commander-in-chief, with the Admiralty as sponsors; and though practically demonstrated to be unsafe and dangerous, yet so determinedly is it forced upon officers, that all ships are ordered to be fitted with it before being reported ready for the pennant: and should an officer still pertinaciously make special application for a more efficient anchor, every species of chicanery is put in force to defeat the object, which would render a direct denial preferable.

"Under these circumstances, H. M. S. *Queen* put to sea without a *Porter's* anchor, which her two former Captains specially applied for.

"Some extraordinary statements, well authenticated, have been made to us relating to anchors and anchor contracts; this latter, however, is a subject more within the province of the Committee on naval expenditure. Our present object is simply to direct attention to a particular fact within our own knowledge; which is, the inefficiency of the anchors now issued to Her Majesty's ships.

"This the Admiralty, or any member of the House of Commons, can also assure themselves of, by calling for returns of the number and description of anchors which have broken in service, particularly from those of Her Majesty's ships under the command of Sir Charles Napier in the Tagus, and Sir W. Parker in the Mediterranean; for it is scarcely to be expected that subordinate officers will spontaneously and officially report against the adoption, or *abortion* rather, of their chief, though special reports are sometimes paraded which the facts recorded in the ship's logs contradict."

To missives such as this we may attribute the appointment of the Committee of 1852; the obvious intent of the writer being to force the Board of Admiralty to a more general use of Porter's anchor—forgetting that the reports of its merits were so conflicting as to prevent their Lordships from coming to a conclusion on the subject. The propriety of their conduct in this particular is singularly established by the fact that Porter's anchors are now superseded by the improvements of Trotman; and the still more important fact that this much-vaunted anchor failed before the Committee at Sheerness (*vide Report, paragraph 8*):

"The lower fluke not opening until it had been drawn through 54 feet, thus confirming in a striking manner the reports that had been made of this anchor occasionally failing to bring ships up!"

"Trotman's improvements," it is said, will obviate this defect; but the condition—"in any ground of sufficient con-

sistency to bear the weight of an anchor,"—sounds oddly enough; particularly as Trotman's improvements are not yet brought into general use. The Committee very properly abstained from the expression of any opinion upon this point.

The Admiralty anchor was also declared to be deficient in *strength*, as well as in *nipping and holding* properties.

In a pamphlet published by Porter & Co., on the subject of their anchor in 1846, at page 19, is a statement purporting to be—

"Comparative tests of strength, ordered by the Right Hon. the Lords Commissioners of the Admiralty, at Her Majesty's Dock-yard, Woolwich."

The result, as shown under this head, is, that Porter's anchors are "*172 per cent. stronger than the Admiralty anchor.*" The absurdity and injustice of this conclusion I have endeavoured to exhibit in my letter on the subject of the appointment of the Committee, addressed to Capt. Peter Richards, C.B., Superintendent of Chatham Dock-yard, dated 14th November, 1851.

At the closing of "The Great Exhibition,"—where, during several months, (namely, from May to October,) proprietors of *patent* anchors had, from day to day, used all their means for decrying the Admiralty anchor, and modestly praising their own inventions, to a very questionable and mixed auditory,—a grand trial was got up, as reported in "The Times," Tuesday, 2nd September, 1851 :

THE GREAT EXHIBITION.

"Yesterday morning an interesting series of experiments took place at the west end of the building, for the purpose of determining the relative merits of Porter's and Rodger's anchors. The trials were conducted in the presence of Mr. Lindsay, the well-known ship-owner, but no satisfactory conclusion was arrived at; and it was arranged that the Admiralty should be invited to examine and decide upon a question in which the whole marine of this country is so largely interested.

"Both the anchors thus brought into competition appear to have a decided superiority over that of Sir W. Parker, which is the one chiefly used in the navy. They differ, however, materially from each other in the principles of construction; the patent of Rodger's having its arms and flukes of the wedge-like form; while in Porter's patent the arms move upon a pivot in such a way that, while one holds in the ground, the fluke of the other presses upon the shank, thus increasing the power of resistance."

After failing to arrive at any "satisfactory conclusion" on the *relative* merits of their own anchors, they invite the Ad-

miralty Board to "examine and decide;" coupling the invitation with the condemnation of the Admiralty anchor!

The parties concerned in these transactions wanting the means for carrying out, on a large scale, a series of anchor trials, they induced certain gentlemen, interested in the Mercantile Marine, to take up the subject; accordingly, in "The Times," 16th October, 1851, we find—

"A memorial from all the leading shipowners of London, Liverpool, and Glasgow had been addressed to the Admiralty, requesting that a public trial may be instituted of the relative merits of the various anchors shown at the Great Exhibition.

"The question being one that affects the safety of life and property, and the welfare of the Government service no less than the shipping interest generally, it is proposed that a committee of naval and scientific officers should be formed, and that a few well-known practical shipowners and engineers should be associated with them in the inquiry."

I am unable to furnish the names of the memorialists. The following, however, appeared in "The Times," Friday, 24th October, 1851:

"The following reply has been received to the recent memorial of the shipowners to the Admiralty, proposing a trial of the relative merits of anchors:—

"Admiralty, Oct. 21st, 1851.

"SIR,—I have received and laid before my Lords Commissioners of the Admiralty your letter of the 13th inst., inclosing a memorial signed by yourself and several shipowners at the ports of London, Liverpool, and Glasgow, praying that a committee of naval and scientific officers may be associated with them for the purpose of investigating and thoroughly testing the relative merits of the several anchors exhibited at the Royal Exhibition.

"I am commanded by their Lordships to acquaint you, that, although the Board of Admiralty have, since the year 1839, made various experiments with a view to ascertain the merits of the different anchors, and adopted the recommendations of the most able and experienced officers and mechanics as to the best description of anchors for Her Majesty's service, they will be glad to afford every assistance in carrying out further experiments to test any improvements that may have been lately introduced in their form and manufacture.

"My Lords will be happy to co-operate in this inquiry with the merchant service in carrying out these experiments, and will communicate further on the subject.

"I am, &c.,

"J. PARKER.

"W. S. Lindsay, Esq.;
"8, Austin Friars."

At this stage of the correspondence I deemed it my duty to call attention to some facts connected with the subject, in the

hope that a more consistent and straightforward course might be pursued than had previously been adopted, particularly towards the Admiralty anchor, and, as a necessary consequence, to the naval service in general. I felt that, occupying the situation of Master Smith in one of the principal Dock-yards in Her Majesty's service, not to speak out at such a juncture, was to betray my trust, and acquiesce, apparently, in the sayings and doings of those whose end and aim were, simply, self-interest. Consequently, on the 14th of November, 1851, I forwarded the following letter; but, from some cause, which I am unable to explain, it was detained in office until the 20th of December; and in this interval the arrangements at the Admiralty were completed, and the Committee named by letter, bearing date, "Admiralty, 6th December, 1851." My request was refused!

My letter of the 16th February, 1848, (when introducing my *portable* anchor,) which appears in an earlier portion of this work,—and that of the 14th November, 1851, together with its inclosures,—require to be placed on record.

The opinions expressed in them having received singular confirmation, they are submitted without alteration or amendment.

[COPY.]

"Chatham Yard, Nov. 14th, 1851.

"SIR.—In the *Times* of Friday, Oct. 24th, 1851, is a letter from the Secretary of the Admiralty, in reply to certain shipowners of London, Liverpool, and Glasgow, who had memorialized the Lords Commissioners of the Admiralty to institute some further experiments on the merits of anchors; which letter states, that their Lordships 'will be glad to afford every assistance in carrying out further experiments to test any improvement that may have been lately introduced in their form and manufacture.'

"I beg respectfully to submit some remarks touching the question in general, and of the means by which it has been brought about.

"For several years past, the public papers have occasionally contained paragraphs condemnatory of the Admiralty anchor. No instance of failure has been allowed to pass without some *ex parte* and highly coloured statements of its inefficiency. Some of these paragraphs have been of a most violent, ridiculous, and even of a scurrilous nature.

"The object of the parties was clearly to induce their Lordships to adopt the patent anchors to the exclusion of the Admiralty one.

"Copies of many of the said paragraphs I have by me.

"The press had apparently laid itself out to work scandal against the Admiralty Board, even to the non-publishing of replies to such paragraphs. Hence the public, *nem. con.*, had settled down into the belief that the Admiralty anchor was untrustworthy—an abortion!"

"Many trials have been instituted to test the relative merits of the

several anchors; but most, if not all of them, are open to very serious objection, on account of the want of uniformity in their weight and general dimensions. To such an extent have these irregularities been permitted, that the inferences drawn from such trials are not only unfair, but preposterously unjust, admitting, in fact, of no fair comparison. One instance will serve to show or confirm this statement.

" See extract (paper marked A) from Porter's pamphlet, page 19.

" To guard against the repetition of such absurdities and foul play in any forthcoming trial, is one of the chief objects of this letter.

The accompanying sketches, B and C, and table of dimensions, D, of the several anchors, will prove how very unsatisfactory must be any trials wherein no care is taken to have anchors of equal weights, and, as far as practicable, of similar general dimensions, tried against each other. The want of this has rendered most previous trials a mere waste of labour.

" The sketch marked B will show that the Admiralty anchor is shorter in the arm and longer in the shank than any of the others; also, that no two of them are alike, and, consequently, must differ in their action: for, as the length of the hypotenuse of the *obtuse* angle decreases, so will the tendency of the anchor to *nip* the ground increase.

" Now, as the lengths of the arms and shanks of the Admiralty anchors are determined relatively with each other in the proportion of *three to one*, it is *not*, strictly speaking, a *short-shanked* anchor. The old plan long-shanked anchors were of the same proportions; probably, this point has been hitherto overlooked.

" Pering's improved anchor is *short-shanked*, and which, when there are any traces of regular proportions to be found, Porter and Rodger appear to have copied.

" Principal dimensions not being *patent*, I would suggest, by way of trial, that a modification of them in the Admiralty anchor would be advantageous. Thus, by shortening the shank the leverage is lessened, and the strength and *nip* of the anchor augmented.

" *Twice and five-sevenths* of the arm taken for the shank will constitute a short shank. In most of Pering's improved, as well as those of Porter's and Rodger's make, the shanks are under these proportions.

" The difference in the size and form of the *palms*, sketches C, is another very important feature, and leaves no room for doubt that the Dutch palm, and which was known in the service a century ago, is a very desirable sort of palm. It nips the ground readily, and presents, as soon as it has entered it, say only a few inches, a much larger holding surface, and will be less likely to *come home* than most others. It is also less expensive to manufacture.

" Rodger has shown it, on his anchors, under several disguises; but still the Dutch palm is clearly developed.

" By letter, dated Feb. 16th, 1848, I called attention to the differences in the length of the shanks and arms of the several anchors, and reference to the paper D will elucidate it in a still more striking degree.

" These irregularities should be obviated for the future by having this part of the question, which is very important, at once decided upon; and, with a latitude of two inches, no anchor should be received into the service that did not conform to such dimensions. This would render the fitments for stowing anchors on board ship uniform; and would save the expense, now often incurred, of altering the said fitments when the ship has been commissioned.

"Anchors of the same weight in cwts. should alone be tried together; nor should an anchor, if it can be avoided, be taken promiscuously from the store to be tried against one *made purposely* for trial, or, at least, it should be most carefully selected.

"This subject having been forced upon the attention of the public by the daily decrival of interested parties at 'The Great Exhibition,' and knowing how unfairly the subject has been treated, and how much depends on the character and arrangement of any forthcoming trials, I am induced respectfully to submit these papers for your consideration.

"As my anchor comes within the conditions named by their Lordships, 'To test any improvements that may have been lately introduced in their form and manufacture,' I beg to be allowed to have one made for trial, introducing some modifications, such as are herein intimated; and which, if found to answer well, may hereafter be introduced, at the pleasure of the Lords Commissioners of the Admiralty, into the Admiralty anchor, which, with many excellent qualities, is still susceptible of improvement.

"It should be observed on the subject of failures recorded against the Admiralty anchor, that full 75 per cent. of the fractures are in anchors of the contract make; and their 'coming home' is often the result, more or less, of the finish of the points, and irregular curve of the arms, and greater length of shank.

"Apologising for the extent of these remarks, which is unavoidable on so large and important a subject,

"I have the honour to be, Sir,

"With great respect,

"Your obedient, humble servant,

"GEORGE COTSELL.

"Capt. Peter Richards, C.B.,

"Superintendent, &c., &c., &c., H. M. Dock-yard, Chatham.

"P. S. In six years, only one Admiralty anchor has been returned into this yard defective, and that one (a contract-made one of 6 cwt.) broken in the shank; and the part had the appearance of having been 'over-heated' in the process of manufacture. So much for fractures!

"G. C."

(A.)

[COPY.]

Extract from *Porter's Pamphlet*, page 19.

"Comparative tests of strength ordered by the Right Hon. the Lords Commissioners of the Admiralty, at H. M. Dock-yard, Woolwich:—

"Test of Admiralty Anchor."

	Proof.	Broke at	Over Proof.
96 cwt. . . .	66 tons	68 tons . .	2 tons . viz. 3 per cent.

"Tests of Porter's Anchors."

	Proof.	Broke at	Over Proof.
5 cwt. . . .	8½ tons	21½ tons .	13 tons, viz. 157 per cent.
10 " . . .	12 "	42 "	30 " " 250 "
28 " . . .	27½ "	60½ "	33 " " 120 "
			3) 527
			175
Deduct Admiralty			3
			172

"Total average, 172 per cent. stronger than the Admiralty anchor."

Small anchors being always infinitely stronger in proportion to their weight than large ones, such trials are not only unfair, but lead to erroneous conclusions.

Porter's anchors had the "vantage-ground" even before the trials commenced; invert the order of the trial, *as to weights*, and the result would have been in favour of the Admiralty anchor.

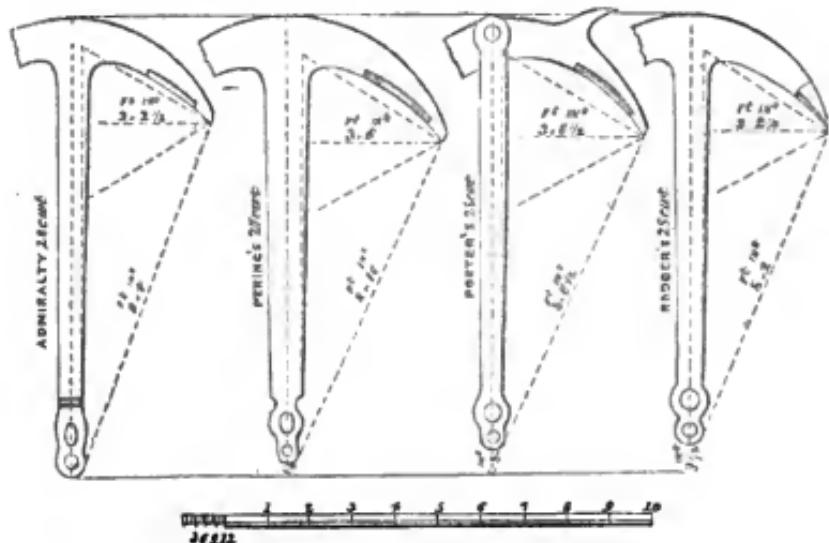
G. C.

(B.)

[COPY.]

Relative proportions of four Anchors in store at Chatham Yard.

G. C.

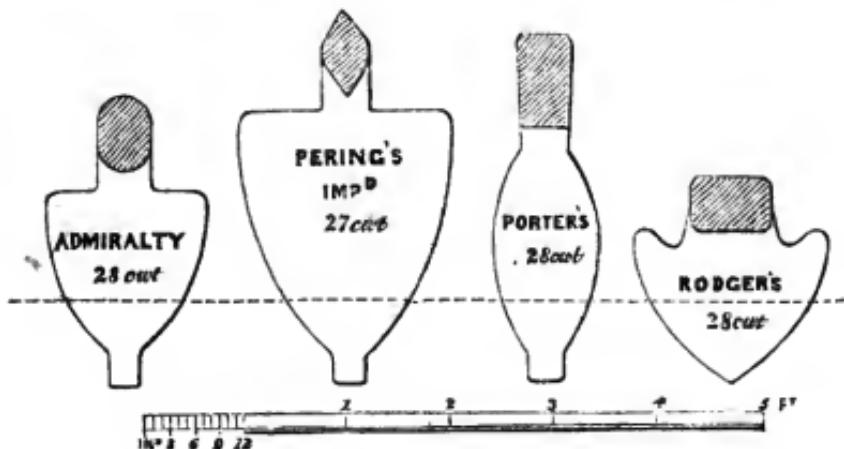


N.B.—There was no 28 cwt. of Pering's improved in store.

G. C.

(C.)

[COPY.]

Relative dimensions of the "Palms" of the Anchors shown in Paper B.
G. C.

(D.)

[COPY.]

Disparity in the length of shank and arms of Porter's and Rodger's anchors, relatively with those of the Admiralty plan :—

Plan.	Weight in Cwts.	Length of Shank.		Length of Arms.	
		Ft.	Ins.	Ft.	Ins.
Admiralty . .	60 . . .	14	5 . . .	4	9½
Porter's . .	60 . . .				
Rodger's . .	60 . . .	13	5 . . .	5	1½
Admiralty . .	55 . . .	14	0 . . .	4	8
Porter's . .	55 . . .	16	2 . . .	5	1
Rodger's . .	55 . . .				
Admiralty . .	54 . . .	13	11 . . .	4	7½
Porter's . .	54 . . .				
Rodger's . .	54 . . .	13	1½ . . .	5	0
Admiralty . .	53 . . .	13	10 . . .	4	7½
Porter's . .	53 . . .	12	7½ . . .	5	0
Rodger's . .	53 . . .				
Admiralty . .	51 . . .	13	8 . . .	4	6½
Porter's . .	51 . . .	15	5 . . .	5	1
Rodger's . .	51 . . .	13	1½ . . .	4	10
Admiralty . .	45 . . .	13	1 . . .	4	4½
Porter's . .	45 . . .				
Rodger's . .	45 . . .	13	3 . . .	4	9
Rodger's . .	45 . . .	12	3 . . .	4	7½
Admiralty . .	28 . . .	11	3 . . .	3	9
Porter's . .	28 . . .	10	7 . . .	4	1
Rodger's . .	28 . . .	10	5 . . .	3	10½

These dimensions show the most extraordinary irregularities in Porter's and Rodger's anchors. In no one instance are they comparable with the Admiralty, and exhibit on the part of Porter's and Rodger's anchors very glaring differences even in anchors of a similar weight.

G. C.

To this letter the following answer was returned through the Captain Superintendent, dated

"Admiralty, Jan 5th, 1852.

"Their Lordships cannot comply with Mr. Cotsell's request of the 20th ultimo, to be allowed to construct an anchor on the plan therein alluded to."

Hence I was prevented from entering into competition in the trials of 1852 ; as the only anchor of my construction was on board the *Cleopatra* in the China seas. And my motive in submitting modified general dimensions, was, that it might be seen whether such alteration would prove advantageous for being introduced into the Admiralty anchor at a subsequent period.

Although I met with this refusal, others were more fortunate; for both Lenox and Aylen were permitted to have anchors tried which had no previous existence; the latter gentleman being one of the committee, and its most active member. As before stated, on the 6th December, 1851, the Committee was formed, consisting of

Mr. W. S. Lindsay, " Anthony Ridley, " Duncan Dunbar, " William Drew, " George Marshall, " William Phillips,	}	Shipowners, &c.
---	---	-----------------

Capt. Stopford, H. M. S. *London* ;
 Munday, " *Waterloo* ;
 The Master Attendant, Sheerness Dockyard ; and
 The Master of the "Flag" ship ;

to act as a Committee in co-operation with the above-named shipowners, "to determine the relative merits of anchors exhibited at the Royal Exhibition."

Subsequently, two other persons connected with the *naval* service appear on the Committee ; namely,

Capt. Charles Hope, Superintendent of Sheerness Yard ;
 and

Mr. James Tonkin, Assistant Master Attendant, Her Majesty's Dock-yard, Portsmouth.

It must be evident, then, that this Committee owes its existence to the course pursued by Porter and others, as already

pointed out, and to the adroit manner by which that course was seconded, in enlisting the assistance of the shipowners of London, Liverpool, Glasgow, &c., to induce the Admiralty to submit to a series of trials (at the Government expense), the object of which was, to condemn the Admiralty anchor, and set up the *patent* ones in its stead! And which my letter of the 14th November, 1851, was intended to prevent by directing the attention of the Board to such facts as had come under my own immediate observation; and which, together with the suggestions I made therein, were calculated to have assisted in the inquiry, and to have been instrumental in bringing the Admiralty anchor through the trials in a more creditable way than the Report represents it to have done. In all this I was simply performing a duty to the Government which my position appeared to me to demand.

We come now to the *constitution* of the Committee, consisting of shipowners and naval officers; and, looking at the names as they stand, the interests of the shipping community and of the *naval* service are well represented; but the absence of representatives in the *mechanical* departments has called forth the animadversion of those parties whose immediate occupation and character are equally affected by the result, as reported, of the trials at Sheerness and Woolwich.

It will appear strange that no one concerned in anchor-making in all the Dock-yards in Her Majesty's service was selected to attend on these trials; and hence the anchor-making community belonging to the several Dock-yards have derived no information that they may turn to account in the future. Had some two or three persons connected with the subject been selected to attend, from the mechanical department of the several dock-yards; were their presence only with the view to gain information by actual observation; and had they been subsequently called upon individually to report their experience, and how far that experience had been confirmed or set aside by the trials referred to; it is fair to presume, that some useful practical suggestions might have followed such a course. As it is, the trials fail altogether in producing those practical results which the employment of so much valuable time might—and, indeed, should—have produced.

It will be admitted that to the *Mechanical* Departments the efficiency of the Anchor must, after all, be referred, and upon them depend; and that the *Report* does, as a necessary consequence, reflect discredit on the anchor-making body of me-

chanics, whether in the service or out of it, so far as the *Admiralty Anchor* is concerned; therefore, as those persons were put upon their trial, virtually condemned with the Anchor, they should have had an opportunity afforded them for observation and report, as above suggested. I submit that the Committee was composed of *two* out of three essential elements; the *one* most deeply implicated and interested being omitted!

The Committee *report*, that they held a Preliminary Meeting at Sheerness Yard on the 27th of January, 1852; when the following resolutions were adopted:

- " 1. That the Committee approve of Mr. J. Aylen's plan for trying anchors in the Yard being adopted.
- " 2. That Mr. Aylen's plan for trying anchors in the Yard be applied to anchors placed on the beach under water.
- " 3. That Mr. Aylen's plan for trying anchors at sea be adopted.
- " 4. That the trials be open to anchors of all nations.
- " 5. That the weight of the anchors for these trials be 25 cwt., inclusive of the stock.
- " 6. That such of the anchors as the Committee shall consider to have proved themselves superior at the preliminary tests, should be afterwards subjected to such further tests as the Committee may decide, or by means of two steamers at sea, with regard to *holding*, *bringing up*, and tripping.
- " 7. That every anchor, previous to being allowed to enter into competition, must be tested at Woolwich.
- " 8. That the anchors be landed at Woolwich for testing by the 1st of May next; at Sheerness, by the 1st of July next.
- " 9. That the Committee will not hold themselves responsible for any loss or damage that may be sustained by the anchors, nor be liable for any expense in bringing them to, or taking them from, Sheerness."

There is only one of these preliminaries to which an exception may be taken; namely, the 5th; being at variance with the rules and practice of *the Service*; which led to a want of uniformity in the weight of the anchors submitted for trial; and also to an error, as I conceive, in the *proof-strain* to which they were subjected.

The Committee, very possibly, adopted this regulation (the 5th) owing to Rodger's Stocks being heavier than the ordinary stocks; and if so, the anchors should have been subjected to the same amount of *proof-strain*.

In the accompanying Table, copied from the Report of the Committee, the variations in the weight of the anchors and the stocks, the amount of *proof-strain* to which each was subjected, and the results, are set forth.

TEST AT WOOLWICH YARD.

Date. — 1852.	Proprietors. No. of Anchors.	Weight of anchor and shackle.	Weight of stock.	Total Weight.	Proof.	Deflection.	Perma- nent set.	Length of Rod.	Manufacturer.
		c. q. lb.	c. q. lb.	c. q. lb.		1st arm + 2nd arm	1st arm + 2nd arm	1st arm + 2nd arm	
May 3	325 1. Rodger . . .	19 0 8	5 2 14	24 2 22	19 $\frac{1}{2}$	$\frac{5}{16} \times \frac{1}{8}$	0 0	5 8 $\frac{1}{2}$	Fox & Henderson
" 3	2. Mitcheson . . .	21 0 0	4 0 14	25 0 14	21 $\frac{1}{2}$	$\frac{5}{8} \times \frac{1}{8}$	$\frac{1}{8}$	$6 0 \frac{1}{16}$	Holsgrove
3 "	3. Brown & Lenox . . .	20 3 14	3 2 24	24 2 10	21 $\frac{1}{2}$	$\frac{3}{8} \times \frac{1}{8}$	0 0	5 2 $\frac{1}{2}$	Brown & Lenox
4 "	4. Isaac . . .	21 0 14	4 0 3	25 0 17	21 $\frac{1}{2}$	$\frac{1}{4} \times \frac{1}{16}$	0 0	5 3 $\frac{1}{2}$	Brown & Lenox
4 "	5. Trotman . . .	21 1 10	3 2 24	25 0 6	21 $\frac{1}{2}$	$\frac{5}{8} \times \frac{1}{16}$	$\frac{1}{4}$	8 4 $\frac{1}{2}$	Wood, Brothers
4 "	6. Porter. . .	20 3 7	3 2 0	24 1 7	21 $\frac{1}{2}$	$\frac{5}{8} \times \frac{1}{16}$	0	8 1 $\frac{1}{2}$	Wood, Brothers
4 "	7. Rodger (Kedge).	20 1 0	4 3 14	25 0 14	21	$1 \times \frac{1}{4}$ full	$1 \frac{3}{16} \times \frac{1}{4}$	$\frac{3}{16}$	Fox & Henderson
5 "	8. Admiralty . . .	20 2 0	4 0 3	24 2 3	21 $\frac{1}{2}$	$\frac{1}{2} \times \frac{1}{16}$	0 0	5 8 $\frac{1}{2}$	Longridge, 1847
20 66	9. Aylen . . .	21 1 0	3 3 13	25 0 13	21 $\frac{1}{2}$	$\frac{1}{2} \times \frac{1}{16}$	0 0	5 6 $\frac{1}{2}$	Sheerness, 1852

* Not recorded at Woolwich.

† This column, being unusual, has not been recorded at Woolwich.

" CHARLES AERTON,
" Chief Engineer.

" Woolwich Dock-yard, August 4th, 1852."

By this table it will be seen that the anchors differed in weight, from 21 cwt. 1 qr. 10 lbs., the heaviest, to 19 cwt. 8 lbs., the lightest—a difference of 2 cwt. 13 qrs. 2 lbs.; the stocks, from 5 cwt. 2 qrs. 14 lbs., the heaviest, to 3 cwt. 2 qrs., the lightest—a difference of 2 cwt. 14 lbs.! Considering that the anchors are of small dimensions, (25 cwt. inclusive of stocks, as resolved upon by the Committee,) the differences in their weights operate against those nice deductions which such trials demand. The weight of Rodger's Stock, 5 cwt. 2 qrs. 14 lbs., brought the test of his anchor to 19 $\frac{1}{2}$ tons, the lowest test. Now, as the intention seems to be to assist this anchor by a heavy stock of a peculiar form, and as the inventor would argue that a *lighter* anchor of his make would be equal to a heavier one of the Admiralty plan, the inference I draw from this is, that those anchors should have been subjected to a *proof-strain* equal to the weight of both anchor and stock. A ship having to carry her *stocks* as well as her anchors, gains nothing by having her anchors lighter by 2 or 3 cwt., and her stocks some 2 or 3 cwt. heavier; although under some circumstances she may lose very materially, as many may have done already. The loss of the ship might be the result! It is to be hoped that the ships of the "Royal Navy" may never be subjected to unnecessary peril by an overstrained economy as to the weight of the anchor. The proper proportion for an *iron* stock is 20 per cent. of the weight of the anchor; Rodger's stock is from 29 to 30 per cent. The result of including the stock in the prescribed weight, 25 cwt., is, that we have three sizes of anchors; namely, 19 cwt., 20 cwt., and 21 cwt.; and consequently, not issuable to the same class of ship. This want of uniformity lessens materially the value of the trials.

The quotations under the head of "Deflection" in the table require explanation: as only *one quotation* is usual in each arm, the columns would appear to be erroneous. The notes at the foot of the table ("*Not recorded at Woolwich;" "†This column, being unusual, has not been recorded at Woolwich;") render their import extremely confused and doubtful.

I am unable to understand upon what ground *two* of Rodger's anchors were permitted to enter the list, when only one of any other sort was introduced: and, as was proved during the trials, "no advantage could result from substituting the former (Rodger's Stream-kedge) for the latter (his *Bower*) in any subsequent trials." (See Report, page 6.) It is clear that the *shipping* interest is not consulted in having a "stream"

or "kedge" anchor, differing in principle or in dimensions from that of the *Bower Anchor*; and the sooner such notions are exploded the better. Indeed, this "Stream-kedge (small-palmed) Anchor was drawn through the *parade ground* anchor-age just similar to a plough!

The mechanical and nautical arrangements for the several trials were all that could be wished; and the Committee have, beyond all question, arrived at "honest and conscientious conclusions;" and, therefore, no offence is intended in the discussion of this subject (which they invite), nor in the attempt to qualify or amend their verdict.

The result of all the trials, as shown by the Report, is, that the Admiralty anchor stands *last* but *one* in the order of excellence, according to the "numerical approximate values;" which, however, the Committee state, have "no pretensions to mathematical accuracy or precision," but "were *merely* approximate values," the Admiralty Anchor being taken as the "Standard or Unit." (Page 10.)

TABLE OF APPROXIMATE VALUES.

The Committee then recapitulate the order in which they consider the anchors to stand, with their relative inferiority or superiority to the Admiralty anchor, the value of which is given in the foregoing table, = 18·17, the standard or unit.

Trotman's . . .	1·28	. 28 per cent. superior to Admiralty anchor.
Rodger's . . .	1·26	. 26 "
Mitcheson's . . .	1·20	. 20 "
Lenox's . . .	1·13	. 13 "
Honiball's . . .	1·09	. 9 "
Aylen's . . .	1·09	. 9 "
Admiralty . . .	1,	the standard or unit.
Isaac's . . .	·73	. 27 per cent. inferior to Admiralty anchor.

By the above, the Admiralty anchor has been beaten by six out of seven!

It must be observed that the "approximate values" are open to considerable discussion.

"Strength," which is the chief and indispensable property of a good anchor, is estimated to be 15 parts only out of 160, and "holding at long and short scope," 80. The latter being questions of detail, I object to these approximate values. Hitherto we have held that the quality of an anchor has been always determined by its capacity for the resumption of its original lines when the strain has been taken off, in connection with the amount of "deflection" exhibited when under test. In these two essentials the Admiralty anchor is scarcely second to any. It is a remarkable fact that the Admiralty shank was *not* broken at all, (whilst, with one exception, every other shank *was* broken), showing that the Admiralty *shank* and *arms* are of a good *sectional* form. The additional fact, that "the arm broke off at the crown, at a strain of 56½ tons, the PROOF-strain for the anchor being 21½," is a sufficient answer to the assertion that the Admiralty anchor is deficient in *strength*. The fracture having taken place at the *crown* leads to the inference that it had not been so perfectly wrought at that part as it might have been, as no anchor should break at that part, particularly one of small dimensions, with our present means for effecting sound "*welding*."

I purpose taking each of the properties considered essential to a *good* anchor, as laid down by the Committee, in order to show *why* these are possessed in a greater or less degree by one anchor than by another; and to point out a remedy for any defects the Admiralty anchor has exhibited in testing or in actual service.

It being desirable to narrow the limits of this question as much as possible, and the case being still, as at starting, really between Trotman's, Rodger's, and the Admiralty anchor,—

Isaac's anchor is omitted; because, from its peculiar construction, it was not at all calculated for general adoption, being more curious than useful. See Plate 15.

Mitcheson's anchor is omitted; because the section alform of the shank and arms creates a difficulty in their being "forged," and is not necessary to strength (from the trial of which he withdrew), and because the mode of fitting his stock to the shank was, I conceive, objectionable. See Plate 16.

Lenox's anchor is omitted; because the sectional form of his *shank* and *arms*, although slightly different to the Admiralty anchor, was not in the least improved in strength, simplicity being the high road to strength; and because his "stock" was complicated, and not superior to the Admiralty stock. See Plate 17.

Porter's (Honiball's) anchor is omitted; because it is virtually superseded by Trotman's improved anchor, and because, having failed in a most important particular before the Committee, affords a further confirmation of the defect said to have been previously many times reported. See Plate 18.

Aylen's anchor is omitted; because, being a modification of the Admiralty anchor, like Lenox's, the advantages, such as they are, are more than counterbalanced by the trouble of forging the arms to his section; and the presumed superiority of his anchor, 9 per cent. over that of the Admiralty, being so trifling, and, moreover, founded on data which have "no pretensions to mathematical accuracy or precision," such superiority cannot be maintained if the Admiralty anchor were always carefully formed—the Admiralty anchor used on this trial having been taken "promiscuously from the store," whilst Aylen's and all the others had been most carefully made specially with reference to this trial. There is reason to believe, that had the Admiralty anchor been made specially for trial, the result would have been little, if at all, in favour of the other anchors, which leaves the question at issue still "Q. E. D."

The Admiralty anchor used in these trials was made by Longridge and Co., in 1847, and the result is highly creditable to that firm.

Properties essential to a good anchor, with their "Approximate Values," as reported by the Committee, considered.

1. "Strength computed from the first crack." Approximate value, "15."

Anchors.	Cwt.	q. lbs.	Cracked at	Value.
Trotman's	21	1 10	. . . 51½ tons	. . . 2·22
Admiralty	20	2 0	. . . 48 "	. . . 2·07
Rodger's	19	0 8	. . . 45 "	. . . 1·94

Difference in favour of Trotman's over Admiralty 15 per cent., of Admiralty over Rodger's, 13 per cent., according to the "approximate value" adopted by the Committee; but by the relative weights of these anchors we shall see that they were, as nearly as possible, of equal strength.

The following results of some experiments (reported by "the Committee on Metals" in 1847) on Admiralty anchors, confirmatory of their great strength, are subjoined :

Admiralty anchor	15 cwt.	. . . broke at 40½ tons
" "	15 " . . .	" 39½ "
" "	16 " . . .	" 37½ "

The *proof-strains* for these three anchors amount, together, to 51 tons, and were broken by a strain of 117½ tons, or 130 per cent. over proof!!! What a full refutation is here furnished to the statement of Porter and Co., referred to in my letter of the 14th Nov. 1851, they having, by a series of trials, made it appear that their anchor was 172 per cent. stronger than the Admiralty anchor!*

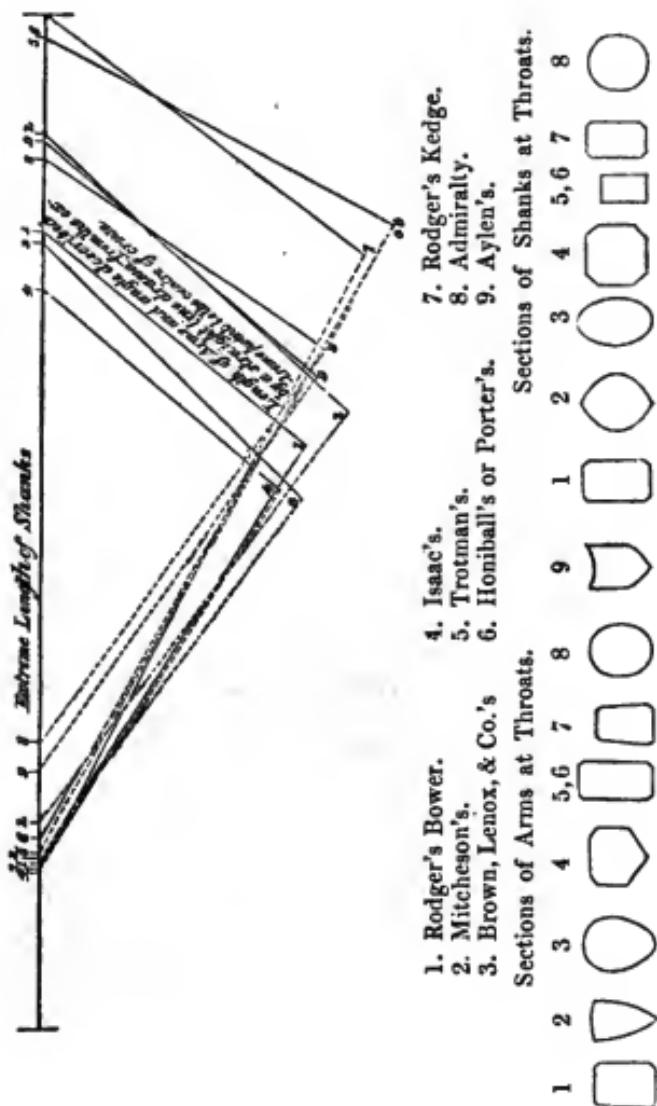
The *strength* of an anchor depends on many conditions; namely, on the sectional form of the shank and arms (which should be as simple as possible); on the contents of the sectional area; on the quality of the materials; on the character of the workmanship; on the length of the shank and arms; and on the degree of temperature to which it may be subject, either under test or in actual use: and I regard the question of strength to be entitled to a much higher numerical value than that accorded to it by the Committee ("15").

For the *sectional* form, length of shank and arms, of the several anchors tried, see Plate 23 (as published by the Committee), which purports to be on "a scale of one inch to a foot," but which is erroneous. For corrected lengths of shanks and arms, &c., see Plate 25.

PLATE 23.

Diagram showing comparative Lengths of Shanks and Arms; also, the Angle described by a straight line drawn from the extreme point to the centre of the Crown of the Anchors tested at Woolwich previous to being tried at Sheerness; also, Sections of the Shanks and Arms; all taken at the same place and drawn to the same scale.

Copied from Report of Committee of 1852.



* * In the original, the Diagram and Sections were said to be on a scale of 1 inch to the foot—they are carefully reduced (for convenience of this work) to $\frac{1}{2}$ inch to the foot, or more properly to one half the size of the original; and, as the original was incorrect, so must the above be equally incorrect. For corrected lengths of shanks and arms, see plate 25.

2. Holding at long and short scope." Approximate value, "80."

Trotman's	.	.	.	.	.	.	14.44
Rodger's	:	:	:	:	:	:	10.69
Admiralty	:	:	:	:	:	:	6.42

This property of "*holding*" at "long and short scope" depends on the length of the arm, on the angle at which it is set relatively to the shank, on the disposition of the *palm*, and on the finish of the *point* or *bill*,—is a question of detail, and not entitled to so high a numerical value as that given by the Committee ("80"). Trotman's anchor, as will be seen by the sketch (Plate 21), has a longer arm, and much greater angle than any of its competitors; and at *short scope* is very possibly assisted by the *horn* at the back of the arm.

Rodger's anchor has generally an advantage over the Admiralty one in respect to length of arm and finish of the *palm*; but the Admiralty anchor is capable of a very great improvement in its *holding* properties. See my letter, 16th February, 1848, the suggestions contained therein having been adopted and embodied in "Cotsell's *Portable Anchor*" with great success.

The undue curvature of the arm at the lower part of the *palm*, as often exhibited in the Admiralty anchor, and the unskilful way in which the *point* or *bill* is sometimes finished, will account for its inferiority in *holding* properties. These defects are easily obviated, and ought never to have existed.

3. "Facility of stowing." Approximate value, "10."

Admiralty	.	.	.	.	.	.	1.82
Rodger's	:	:	:	:	:	:	1.82
Trotman's	:	:	:	:	:	:	.91

In this respect the Committee give the preference to the Admiralty and Rodger's; as this seems to refer to the stowing the anchor after unmooring ship, no doubt the oscillatory principle of Trotman's is somewhat against it.

4. "Quick holding." Approximate value, "15."

Rodger's	.	.	.	.	.	.	2.36
Admiralty	:	:	:	:	:	:	2.01
Trotman's	:	:	:	:	:	:	1.77

This property is dependent on the points referred to under the second head, "holding at long and short scope;" and although the Admiralty holds a respectable position on this

question of *quick holding*, it might be improved by care and attention of the workman. Admiralty anchors passing through my hands for repair, &c., where the finish of the points has been destructive of its *quick holding*, have been improved; the trouble is comparatively none.

5. "Quick tripping." Approximate value, "5."

Admiralty	:	:	:	:	:	:	·89
Rodger's	:	:	:	:	:	:	·67
Trotman's	:	:	:	:	:	:	·31

The Admiralty anchor is placed first in this respect by the Committee. Just in proportion to the *holding* properties of an anchor being good, will its *quick tripping* be lessened. The latter being of slight importance, and as casualties of fracture in weighing will be rare, with the present strength of our anchors, a loss in respect to *quick tripping* is more than compensated for in a matter of greater importance.

6. "Exemption from fouling." Approximate value, "10."

Trotman's	:	:	:	:	:	:	1·85
Admiralty	:	:	:	:	:	:	·65
Rodger's	:	:	:	:	:	:	·64

Trotman's is accorded the preference. If *fouling* be regarded in reference to ships not being liable to ground upon the upper *fluke* of the anchor in shallow water, it is not a question of much importance to the ships of the "Royal" Navy. The accompanying sketch (Plate 24) will, however, show the actual difference between the projection above the anchorage of the Admiralty and Trotman's anchors, the difference being much less than might have been expected from the assertion "that the upper arm of the latter anchor lies flat upon the shank."

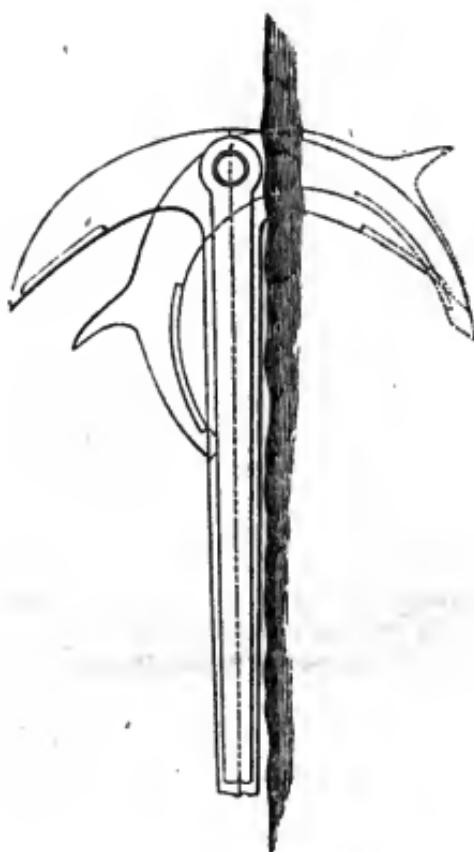
7. "Facility of sweeping." Approximate value, "5."

Admiralty	:	:	:	:	:	:	·95
Rodger's	:	:	:	:	:	:	·95
Trotman's	:	:	:	:	:	:	·29

The facility of "sweeping" is scarcely due to Trotman's, even in the ratio above given; and with some other deficiencies in essential qualities of a good anchor, leave it doubtful whether due value has been accorded to this peculiar property of an anchor. Anchors have frequently to be swept for, and is a very important point.

PLATE 24.

Sketch showing the actual obstruction presented by the *Upper Arm* of Porter's and Trotman's Anchors as compared with that of the Admiralty, when embedded in the same anchorage.



Admiralty 51 cwt.
Porter's 51 cwt.

8. "Facility of transport in boats." Approximate value, "5."

This decision of the Committee is very singular. One of the grand objects contemplated by inventors of *portable* anchors is, the facility they afford for transport in boats. No reasons being assigned for the conclusion to which the Committee came upon this part of the question, it would be useless to attempt to discuss it further. Trotman's anchor being *portable*, seems to entitle it to the highest place in this respect.

9. "Fishing in a heavy sea-way with present fish-hook." Approximate value. "10."

Rodger's	.	.	.	.	.	.	2-19
Admiralty	.	.	.	.	.	.	1-98
Trotman's	.	.	.	.	.	.	.55

The Committee seem to think that the "difficulty of fishing a particular anchor may eventually be overcome by the introduction of a fish-hook specially adapted to such anchor."

If a fish-hook could be invested with the faculty of "sight," the difficulty of "fishing" Trotman's anchor would be overcome. The alteration of the fish-hooks hitherto used in the "Royal Navy," by curving the back of the hook, will, I am disposed to think, not be found eventually beneficial; at all events, an undue importance has been attached to it: the trouble and expense will scarcely be met by the supposed improvement. They lose the character of fish-hooks.

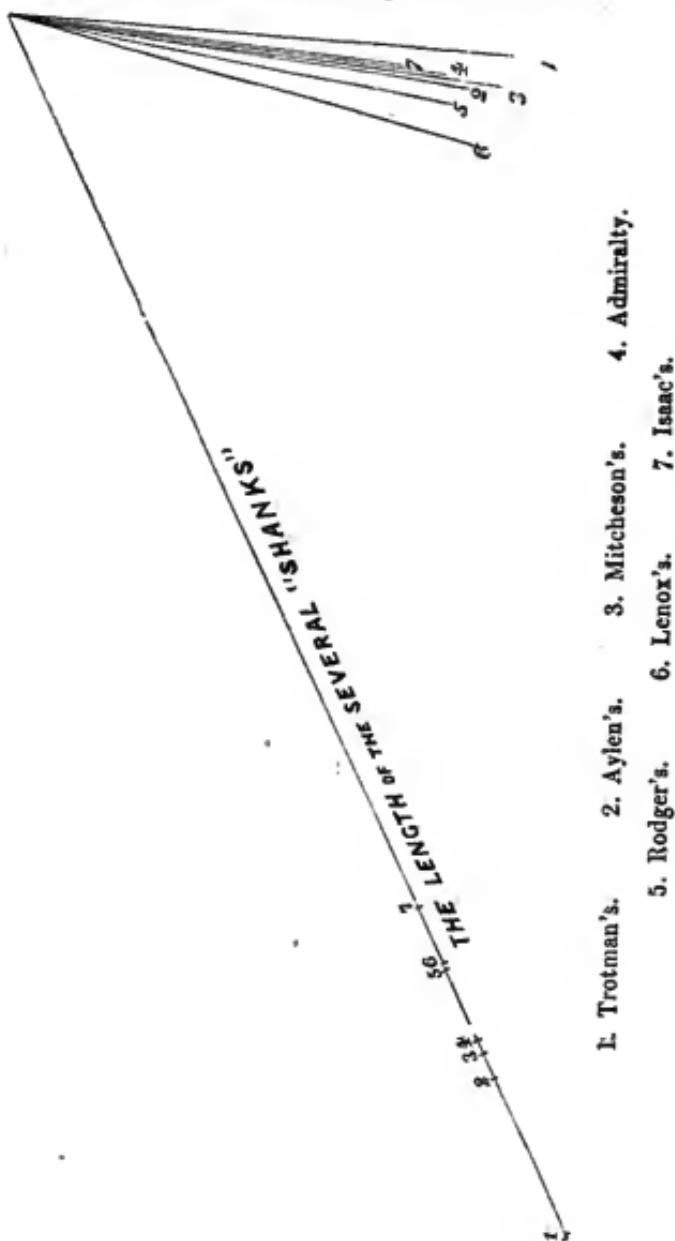
10. "Canting." Approximate value, "5."

Admiralty	.	.	.	.	.	.	.	73
Rodger's	.	.	.	.	.	.	.	73
Trotman's	.	.	.	.	.	.	.	55

Trotman's is again deficient in the property of "canting;" the extreme length of the arm, giving so much larger an angle, will readily account for this difference. It is evident that, as an anchor is very liable to fall with the "flukes" flat, the canting quickly is important, as it cannot act till it has been canted; and as anchors on Porter's principle will be further liable to remain closed, as was seen at the trial, it is necessary to ascertain by actual use whether Trotman's improvements have removed the defect alluded to.

PLATE 25.

The length of the several "arms," and the angle described in each case, corrected to a scale of $\frac{1}{2}$ inch to the foot.



The diagram (Plate 25) is furnished of the correct details of "extreme length of shanks, length of arms, and angle described by a straight line drawn from the extreme point to the centre of the crown," to supply the place of that published by the Committee, which is incorrect. In the diagram now presented, all the lines are made to centre at the crown, which will, it is hoped, render the differences existing in the anchors tried more easily understood by non-mechanical men.

This diagram shows the length of arm and angle of Trotman's anchor to be much greater than any of the others, which led the Committee, whilst awarding it a greater *holding* power by 24 per cent. than the Admiralty anchor, to qualify the statement with the very dubious words, "With a steady equitable strain." There can be no doubt that *ordinary-made* anchors of Trotman's plan, if constructed on similar dimensions, would be found less efficient under stress of weather with a ship riding heavily in a chopping sea.

It would not have been at all difficult for any man, whose attention had been previously well directed to the subject of anchors and their essentials, to have foretold, on a careful inspection of the several anchors tried, nearly all their characteristics; and a personal inspection of the *debris* of these anchors would have afforded to a practical man an amount of information which he looks for in *the report* in vain. The *models* prepared and forwarded with the report, can convey nothing like the information so large an experiment as the breaking some seven superior-made anchors was in itself calculated to impart to a practical and inquiring mind.

By the diagram now furnished we see the want, or absence, of any well-digested plan for insuring uniformity of dimensions. After so many years of experiment, and such an opening for the adjustment of the relative dimensions best suited for general adoption, we find the Committee altogether silent on the subject; which is the more singular, when we examine the matter in reference to the anchors brought forward for trial, and the necessity that exists for the adoption of some general rule in this matter; for, whether in the Royal Navy or in the Mercantile Marine, it is indisputable the question should no longer remain open for each to choose. The question of *general* dimensions will, I feel certain, force itself sooner or later upon the attention of the authorities; it cannot be supposed rational to have those glaring differences such as are seen in the seven anchors professedly of the same weight.

The following is the case :

The longest shank (measured from the centre of the crown, and which was the same in all the instances referred to) was 11 feet; the shortest, 8—difference, 3 feet! The longest arm was 4 feet 5 inches; the shortest, 3 feet 4 inches—difference, 1 foot 1 inch!! The angles were all different; and in disposition, size, and finish of the “palms,” and in the sectional form of the shanks and arms, no two of these seven anchors were alike!!! It is high time, then, that some more rational system should be adopted for regulating the *general* dimensions best adapted to all the exigencies of the two services. There can be no need of more than one scale of general dimensions, and that should no longer be left undetermined.

Nothing can well be more unsatisfactory than the attempt to draw comparisons of strength between anchors whose general dimensions and other particulars vary as did those tried at Sheerness.

Until we shall have fairly weighed and duly determined what are the best principal dimensions for anchors, and are prepared to enforce their general adoption, so far as we may be able to enforce them, we shall arrive at no satisfactory settlement of the questions in dispute.

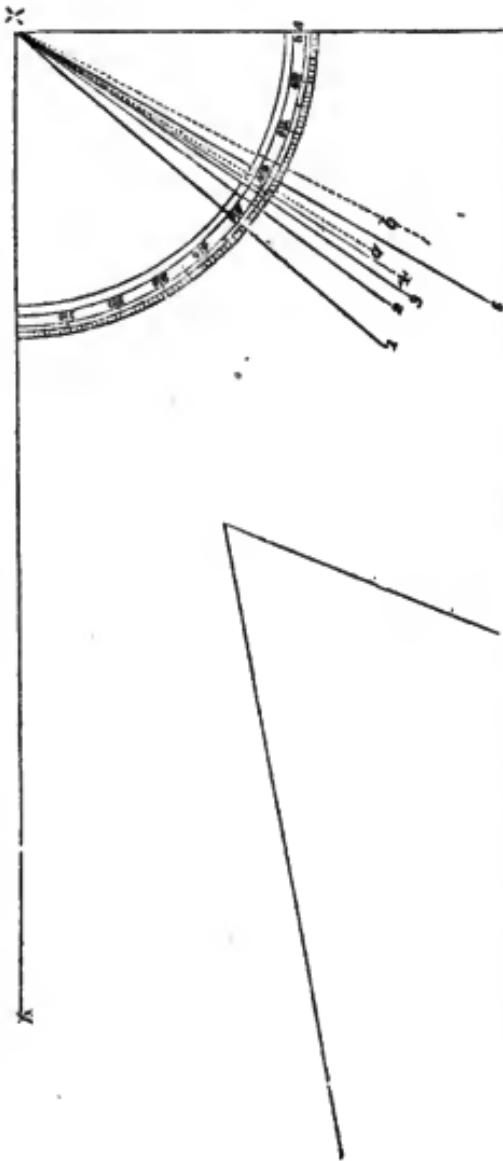
Can it be reasonable? Is it mechanical that such a matter receives no practical solution? Scarcely, indeed, any attention!

The weights of the several anchors are regulated and determined by the tonnage of the vessel; and the lengths of shanks and arms as set forth in the Admiralty scale of dimensions (with a very trifling alteration) would be found to answer admirably; and it is desirable that all anchors should be of one general dimensions, if intended for use in the Royal Navy, or great and unnecessary expenses must be continually incurred in the fittings for stowing them, in the chains, &c.

The following are the lengths of shanks and arms of the several anchors named in the margin; showing the alterations made by Mr. Pering as compared with the old plan anchor; and also the differences in the above respects of the eight anchors tried at Sheerness—the latter being now denominated 20 cwt. (which they should have been but for the difference in the weight of their stocks), for the sake of apportioning their relative differences in general dimensions.

PLATE 26.

The lines 1, 2, 3, 4, and 5 show the angle of the arms, respectively, of five of the Anchors tried at Sheerness in 1852 : the dotted line *a*, the angle of the French Anchor; and *b*, of the Dutch, Danish, and Swedish anchors of fifty years ago ; the line *x x* being the shank in each case.



Showing that all anchors have their bases upon two straight lines; and, of whatever form or plan, ultimately resolve themselves into these, differing only in the degree of angle or other matters of detail.

Description of Anchor.	Cwt.	Length of	
		Shank.	Arms.
The Old plan anchor of	20	12	4 3½
Pering's 1st plan anchor	20	12	4 3½
Pering's improved	20	9	3 8½
The eight anchors tried at Sheerness in 1852.	Admiralty Rodger's Trotman's Lenox's Aylen's Mitcheson's Honiball's (Porter's) Isaac's	20	10 0½ 3 2
		20	9 0 3 2
		20	11 9 4 1½
		20	9 1 3 2½
		20	10 2 3 4½
		20	10 0 3 8
		20	11 9 4 0½
		20	8 6 2 9

The above will serve to show the necessity for the adoption of the best general dimensions for anchors in order to do away with the irregularities complained of. The next point is, the difference of the angle described by a straight line of the several anchors named in the diagram (Plate 26), and which calls for amendment. In the seven instances given there will be found a difference upon the whole of thirteen degrees! In this matter, as in most others, something between the two extremes will be the most eligible point. Take fifty-eight degrees as the angle for the arm of the anchor, and you will not have any reason to complain of its working, provided other matters of detail have been attended to.

There will be differences of opinion as to the length of shank best suited for general use; but now that chain cables are almost universally used, long shanks are discarded, the use of chain cables with long shanks being calculated to break the anchor.

There can, however, be but one opinion, that the dimensions exhibited in the foregoing table are such as to call for inquiry and amendment.

Approximate Values.—A Table of Approximate Values of the properties considered essential to a good anchor, which is submitted as being nearer their relative value than that adopted by the Committee.

Essential Properties.	Approximate Values.
"Strength," compared from 1st crack	45
"Holding," at long and short scope	30
"Quick holding"	15
"Canting"	15
"Facility" of sweeping	15
"Facility" of stowing	10
"Exemption" from fouling	10
"Fishing"	10
"Facility" of transport in boats	5
"Quick" tripping	5
Total values	160

I have accorded, and justly so, I conceive, the highest value to *strength*. The Old plan anchor, so loudly condemned, had nearly all the more essential properties of a good anchor, *except "strength."* Its deficiencies in this respect, as well as the causes, are fully treated of in its proper place. It will be evident, that as one anchor might possess a certain property in a greater degree than another, it is of the last importance that the approximate values be very correctly set forth.

All the other properties, however highly possessed by an anchor that should prove to be deficient in *strength*, would avail nothing in the hour of peril; and, consequently, I should be disposed to *increase* rather than diminish the approximate value I have already accorded to *strength*.

The Committee accorded 15 as the value for "*strength*." I give 45—the latter is certainly not too great.

The great fact established by the trials at Sheerness, although not duly noticed, is, that one of the Admiralty anchors, *taken promiscuously from the store*, was of equal strength to either Trotman's, Rodger's, Lenox's, or Aylen's, although each of the last mentioned had been most carefully made purposely for this trial!!!

Having already stated the several conditions upon which the *strength* of an anchor depends, it only remains to notice the

Report of the Committee on this point (Paragraphs 24 and 25).

Paragraph 24. "In these trials the rectangular and octagonal shanked anchors having generally proved themselves to be possessed of greater strength than those with round or oval shanks, the Committee submit, that in their opinion it is a question worthy of the serious consideration of the Admiralty and of the mercantile marine, whether, now that chain cables are in such universal use, all anchors ought not in future to be forged with square or angular shanks and stocks, instead of round or oval, as is now more generally the case. They are induced to offer this suggestion, not only on account of what fell under their own observation, but also because several anchor-smiths of experience assured them that they considered greater strength would be thus attained, at a much less cost of manufacture."

Doubtless, the more simple the form of the section, the greater the chance of strength, and the less costly the manufacture. It is curious to observe persons praising a plan which they themselves have not adopted. Anchor-smiths in *the trade* are at liberty to adopt any form they may think proper, and there is no excuse for them if they neglect to adopt the best.

The reason assigned by the Committee for the adoption of square or angular shanks and stocks ("now that chain cables are in such universal use") is the very reason for the avoidance of angular or sharp-edged shanks and stocks, so as to prevent the injury to chain cables which might otherwise ensue; a consideration which, more perhaps than any other, determined the oval form of the Admiralty anchor. It is most singular that Trotman's and the Admiralty anchors are the only two that can claim a preference to simple and regular forms; whilst all the rest are more or less fantastically shaped; evincing a want of that matured judgment so necessary upon this subject. In proof see Diagram of Sections of the Shanks and Arms of the several Anchors tried, Plate 23.

Paragraph 25. "In *two* cases—viz., Aylen's and Lenox's—their apparent want of strength may be attributed to a cause which the late Mr. Pering pointed out in his treatise, published in 1819, p. 52, that 'Many anchors for want of this process (annealing), have broke, and particularly in our dock-yards, the smith being too fond of finishing his work by polishing the surface with the hammer.'"

This assertion is very far-fetched, and conveys an unmerited censure, the *cold* "hammering" practised in his (Mr. Pering's) day being now and for many years discontinued;

and the only *polishing* an anchor now gets is at a low heat, and any hardness of surface this process may have superinduced is removed by the *annealing* which always follows on the completion of an anchor in the Dock-yard smitheries; namely, by well roasting over the anchor-forgé with wood, &c., throughout every part. See "Annealing."

There was no want of strength in either Aylén's or Lenox's (except by comparison), both being more than 100 per cent. over proof, but both inferior to the Admiralty anchor in this respect, although made specially for trial.

For the improvement of the Admiralty anchor the Committee recommend (page 10, p. 33):

"1. That the *pee* of the anchor should be chisel-pointed, to give the arm a greater inclination to enter the ground.

"2. That the head of the palm should be cut down a little towards the arm, so as to give a better hold to the fish-hook.

"3. And the sides of the palms should be set back from the middle upwards, until the edges are even with the centre of the arm, to admit of the earth passing over, and thereby obviate the great tendency to 'shoeing' which the Admiralty anchor exhibited on the Parade Ground."

The paragraph as printed in the Report was not subdivided as above; I have adopted this mode for convenience in discussing the several recommendations separately.

To the second proposition I consent. The practice of continuing the "palm" beyond the *blade* is objectionable, and tends to prevent the fish-hook from getting that close hold upon the *small* of the arm which is desirable—nay, necessary—for quick and effective "fishing" of the anchor.

To the first and third propositions I most decidedly object.

To the first, because it is unnecessary, unsightly, and will not give the arm a greater "inclination to enter the ground," except at a very short scope of cable; and even then, a well-formed "point" or "pee" will do all that is proposed, both at long and short scope. See Plate 24.

To the third, because the object sought to be accomplished by the setting back of the palms—namely, to "obviate the tendency to shoeing"—will be much more effectually secured by the setting the *inner* surface of the palms straight, as previously recommended; and because the plan of setting back the palms (as recommended by the Committee) will be sure to lead to serious malformations, and is in itself extremely unsightly. Moreover, the "Cleopatra's" anchor, most ex-

tensively employed in all sorts of anchorage, exhibited no tendency to "shoeing;" on the contrary, "as an anchor it did its work well, and held the ship in all weathers." The mode adopted in disposing of the "palms" of this anchor is simple, efficient, and therefore worthy of adoption generally. See Plan for an Improved Admiralty Anchor, Plate 29.

The alleged "inefficiency" of the Admiralty anchor considered; the causes which have led to its "inefficiency," and the means for preventing their recurrence, explained.

It will be asked, Are the Admiralty anchors so "utterly inefficient" as they have been represented to be? The answer is, No. Instances are on record in which their efficiency has been proved in a most striking and satisfactory manner. This brings us to consider, *why* they are not always equally efficient?

The truth is that these anchors have been made by too many parties—numbers of them without the slightest supervision during the progress of manufacture. The result has been that want of uniformity in the make and finish of these anchors so often met with, as set forth in my letters of the 16th February, 1848, and 14th November, 1851, whereby their efficiency has been impaired.

When we consider the number of dock-yards in which these anchors are made,—that they are also made by *two or more contractors*,—and reflect upon the fact, that errors of judgment, want of due care and attention, self-interest, and almost a total absence, it may be said, of responsibility,—have each contributed in turn, to the bringing about those defects of the Admiralty anchor, and most unfairly ascribed wholly to the principle of its construction,—

The charge of *want of strength* so much urged against the Admiralty anchor can no longer be maintained. *Fractures* must, hereafter, be ascribed to the quality of the material, the mode of applying it, the character of the workmanship, or to rough usage. Nor must we expect perfect freedom from casualties in the make or use of anchors. We have good ground for hoping that the means are with us for rendering them less frequent, if we employ those means honestly and carefully.

The instances of fracture, will, if I am rightly informed, be found to be chiefly with anchors of *contract* make: mal-formations belong equally to those made in the dock-yards and those

made by contract. Both these evils are suggestive of the necessity for some more effective supervision than has hitherto existed.

I should tire in attempting to record the numerous instances of mal-formations that have come under my own notice ; a few instances will suffice, as the object in hand is to apply a remedy.

The *holding* properties of the anchor are secured by mere matters of detail ; and lost by a want of knowledge or attention to details. The great difficulty, where many parties are concerned, separated by great distances, is, to preserve a *uniformity* in their modes of working, and to keep them within the limits of the drawings furnished for their guidance. If, for example, we were to take an anchor made by each of the several Dock-yards, also one made by each of the contractors for anchors, and place them side by side, we should find them to differ in some particular ; and these differences of form and finish tend in a greater or less degree to impair the efficiency of the anchor.

Now, all are supposed to be guided by the same rules, and to be working from drawings which are, it is presumed, copies of each other. This fact serves to show the tendency there is for deviating from established rules where large numbers of persons are concerned far removed from each other, and points to the necessity for some more effective supervision than exists at present.

Plate 27, figs. 1, 2, 3, is intended to show the kind of arm adapted to the present Admiralty anchor. It differs slightly from the Admiralty drawing, which a practical eye can alone perceive ; this kind of arm I have of late adopted when making anchors in Chatham Yard.

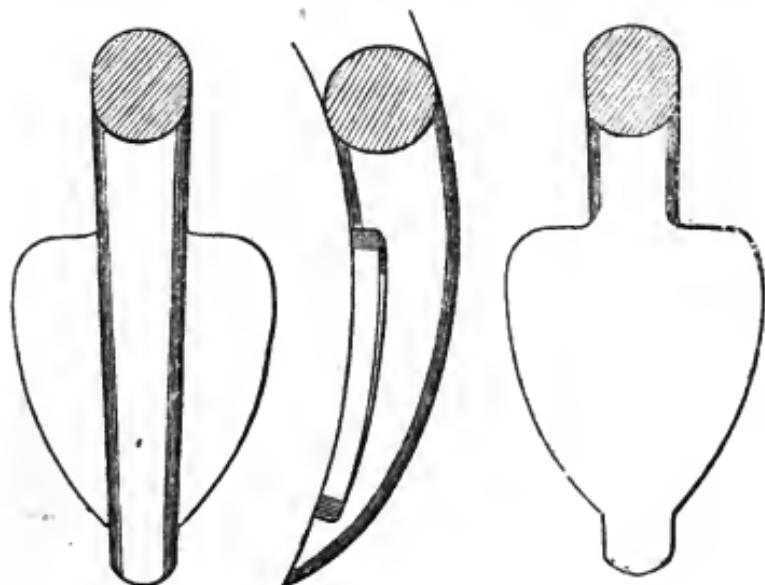
Plate 27, figs. 4 and 5, exhibits the kind of arms sometimes met with in the Admiralty anchor ; the finish of the points being so formed that it is next to impossible it could enter any hard anchorage. The difference of these, and the arm described by figs. 1, 2, 3, is too manifest to need further remark.

Plate 28 is intended to show the probable results of an undue curvature of the "palm" near the point, when moored with the several scopes of cable indicated in the sketch : a careful examiner will perceive that even with 100 fathoms run out the anchor is not well set to resist great strains in a chopp-ing sea, and at "*short scope*" will actually forsake the ground rather than seek to enter it.

PLATE 27.

Figs. 1, 2, 3.

Drawings showing the kind of arm adapted to the present Admiralty Anchor.

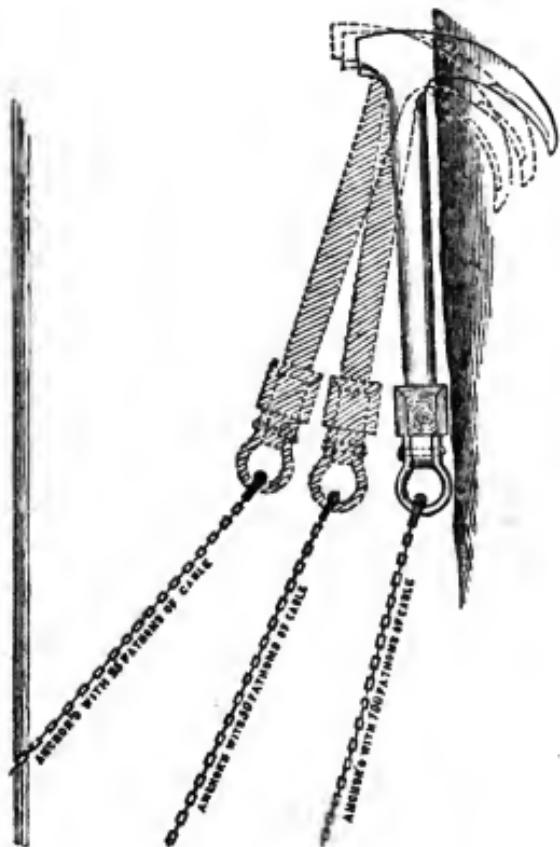


Figs. 4, 5.

Drawings showing the malformation of the points or "pees" of the Anchor, which prevent its entering the ground. Two examples met with in the Admiralty Anchor.



PLATE 28.



One reason why contract-made Admiralty anchors have often proved inefficient, is the manner in which they are "jobbed out" to various firms for manufacture; let the following instance, in illustration, suffice.

Suppose a number of anchors being ordered by the Board of Admiralty of a contractor; he goes to another firm and bargains for a number of shanks and arms of sizes, at per ton; and perhaps this second firm, finding itself unable to comply with the order, goes to a third; another bargain is struck—all, of course, being intent upon the amount of profit to be realised; and presently these parts of anchors find their way into the hands of the contractors, who again bargain for their being brought together and completed. Can any looser system, or one fraught with more liability to mischances than this, be imagined?

Hence anchors for Her Majesty's navy are not only made without any attempt at supervision, but the contractors themselves often know nothing whatever of the character of the iron—the way in which it is disposed—nor, in some instances, how the parts are brought together. In fact, they are often brought together totally different from the manner pointed out in the specifications of the contract—and in an objectionable manner!

The remedy for this, and the only really efficient one, is, the establishment of an anchor-factory for the manufacture of all anchors for the "Royal Navy"; and if, hereafter, from any cause, anchors should be made by contract, an intelligent officer from the smith's department should be appointed as "inspector" of contract work, not necessarily stationed at the firm, but having at all times free access to the works to note and check any informality in carrying on the work.

The establishment of an anchor-factory need not involve any great increase for labour over and above the number considered equal to the requirements of the service. It is well known that the number of smiths in proportion to the number of shipwrights is inadequate to meet the increasing demands for iron-work; and that, consequently, anchor-work has been almost abandoned in some yards. Were the established number of smiths increased to two-sixths the number of shipwrights, a selection of firemen and skilled hammer-men might be made from the several Dock-yard smitheries to man the anchor-factory; which, being placed in charge of an officer of ability, an improvement in the matter of anchor-making, and

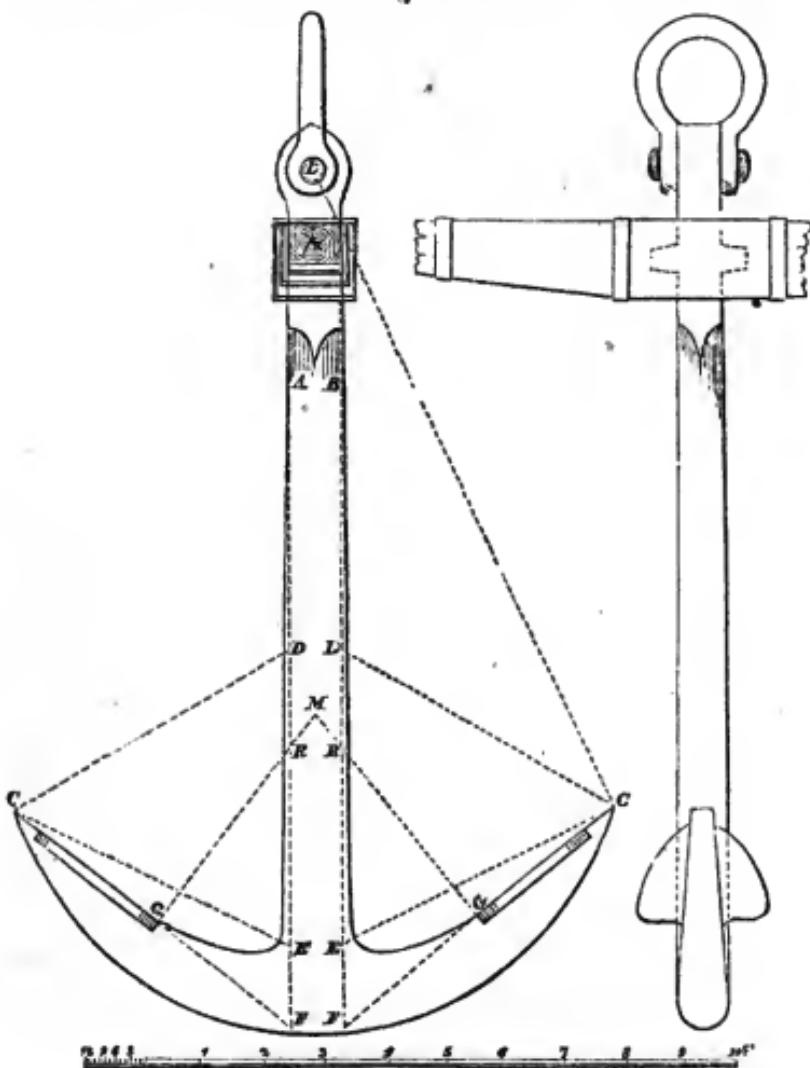
a general uniformity of make and finish, would be insured that could not reasonably be expected to obtain under the present or any other similar arrangement ; and thus your smitheries would be wholly devoted to the manufacture of ship-work—your anchor-factory, to the making of anchors only : and if the arrangements were judiciously made, an amount of perfection might be expected as the result that would leave no room for cavil or complaint.

The present smitheries might require some additional accommodation for the increased number of smiths found necessary for keeping pace with the requirements of the service ; and the establishment of an anchor-factory would, consequently, not involve a totally additional expense to the Crown. In other words, the plant of the present smitheries would require a larger outlay, in the event of the anchor-smithery not being allowed, than need be entered into, should an anchor-factory be established.

PLATE 29.

COTSELL'S Improved Admiralty Anchor.

Draw two lines parallel to each other, whose distance apart shall be equal to the small of the shank $A\ B$; on either line describe the equilateral triangle, $C\ D\ E$, whose side shall equal the length of arm; produce $D\ E$ to F ; $E\ F$ equals the size of the throat; join $F\ C$, and bisect it in G ; from the point G erect the perpendicular $G\ M$; then, with M as a centre, describe the curve $C\ F\ C$, and from the point X describe the arc $G\ E$; draw $C\ L$ equal to twice $C\ R$; the point L will be the centre of the shackle-boil.



A TREATISE ON SHIPS' ANCHORS.

PART III.

COTSELL'S CONSTRUCTION FOR AN IMPROVED ADMIRALTY ANCHOR.

In submitting the accompanying sketch for an *improved* or modified Admiralty anchor, I have a well-grounded conviction of its utility.

It embraces those points for which I have frequently contended ; and the propriety of which experiment has served to establish.

The differences between it and the Admiralty anchor are apparently trifling, yet sufficient for the purpose of correcting those defects to which the Admiralty anchor is frequently obnoxious.

The proposition embodies those points already found to have answered well in "Cotsell's Portable Anchor" (supplied to the Cleopatra in 1849, and now on board the Tartar, in the Baltic), with one or two additional points tending to perfection in those properties considered essential to a good anchor ; and for which the careful reader of the foregoing pages will have been prepared.

The plan has been to take the Admiralty scale of dimensions for the length of the *arm*, and determining the length of *shank* in the manner described in the sketch. The length of lever being, as a matter of course, at the centre of the shackle-bolt (*L*), all below that point only adds to the weight, not to leverage.

By this mode of construction the length of the shank will be 5 per cent. less than the Admiralty shank, and by simply working the parts full to the scale the amount of iron lost in length of shank will be deposited equally over every other part of the anchor ; hence it will obtain an increase of strength in

a two-fold manner ; namely, by diminishing the length of lever (shank), and slightly increasing the sectional contents or area.

The *external* curve of the *crown* and arms exhibits a true segment of a circle ; whilst the inner surfaces of the palms are kept straight ; the former increasing the tendency to easy “tripping,” and the latter facilitating its properties for quick nipping and greater holding, both at long and short scope, than an anchor with curved palms, as exhibited in the Admiralty anchor ; and removes, moreover, the tendency to “shoeing” referred to in the Report of the Committee of 1852.

The “blade” of the anchor is also reversed, causing it to present its broadest surface to the palm, which alteration, increasing the width of the “point” or “pee,” further improves its nipping or holding properties.

The plan of construction being fully set forth on the sketch it only remains to enforce its adoption on those who are desirous of being provided with a simple or common anchor, combining, with great strength, all the other requisites for use and safety.

It was such an anchor as is herein described I was desirous of introducing into the trials of 1852 ; believing then, as now, that had I been permitted to enter into competition on that occasion the Admiralty anchor would certainly have found an advocate whose aim would have been to set forth with truthfulness its defects—who were to blame for their continuance—and to have shown how readily those defects might have been obviated or removed.

The plan of construction herein recommended affords the anchor-smith a ready means of ascertaining the proper curvature of the arms and crown. A reference to the drawing (Plate 29) will show that if a “straight-edge” be applied to the *inner* surface of the “palm,” longitudinally passing over the arm, it will cut or impinge the external arch of the *crown* at the point *r* ; and this fact will assist the workman greatly in determining the form of the arm even before it is *brought on* to the shank itself. A skilful anchor-smith will not fail to get the arm and palm well set prior to “*shutting up*,” by a very simple process, and the application of the *straight-edge* as already described.

There is not the slightest additional expense involved in carrying these directions into execution. The plan promises to effect an ultimate saving.

ON ANCHOR-MAKING.

It would be difficult to point out any article composed of iron subject to so many casualties, such great and tortuous strains, as an anchor.

Hence every care should be taken to insure its being composed of the best material, and wrought in the most perfect manner that human skill, aided by suitable machinery, are capable of effecting.

Looking at a finished anchor (of which we had seen nothing in the course of its manufacture), the most practised smith is unable to determine either the quality of the iron of which it is composed, or the character of the workmanship bestowed upon it. Externally, the worst description of anchor might be made to appear every way equal to the best. No one can foretell what defects it may exhibit internally when brought into use, or what powers of resistance it might possess.

The anchor-smiths, who are held responsible (as in the Royal Dock-yards) for the quality of the work they may perform, will generally be found to exercise great care in executing their work; and they will be enabled, in most cases, to determine the amount of efficiency of the anchors so made.

To the responsibility of the Government smith is attributable, chiefly, that acknowledged superiority of the Dock-yard-made anchors over those of contract make.

The Old plan anchor, or the one used fifty years ago, was, as we have already seen, composed of very inferior material—indifferently “laid up,” badly “scarfed,” and for the want of suitable machinery, imperfectly welded—called for the exercise of great manual exertion, and was altogether a most dispiriting piece of drudgery.

The use of a much better description and larger dimensions of iron, and some improvements in the “Hercules,” the mode of working and “scarfing” the “arms” to the crown, gave the anchors of Mr. Pering’s plan a decided advantage in point of strength to those previously in use.

The application of steam power to work the “Hercules,” previously worked by hand, the introduction of the fan-blast

in lieu of bellows, and, more recently still, the adoption of Nasmyth's steam hammer and furnaces, leave little to be desired in the way of effecting sound and efficient work, so indispensable in large and important articles, such as an anchor, and have happily relieved the workmen of that excessive drudgery hitherto inseparable from anchor-making.

To the anchor-smith simplicity of *sectional* form is an important feature. When this has been studied by inventors, or designers, the smith is enabled to produce good work at a moderate cost.

The most simple *sectional* forms are square *a*, rectangular *b*, round *c*, and elliptical *d*, as described in the sketches; and



any departure from these tends not only to increase the labour and cost of production, but is further likely to result in some defects of workmanship owing to the greater skill required to produce them.

The facilities afforded by Nasmyth's hammer have greatly simplified, as well as improved, the mode of forging the component parts of the anchor, all of which are now made of scrap-iron.

Shanks, arms, palms, and shackles for anchors of all sizes up to 5 tons weight, and stocks for anchors up to 60 cwt.,* are now forged under the steam hammer; and the work of the anchor-smith is, consequently, limited to the bringing the parts together, and in forming and finishing to the required scale.

The change thus effected in the machinery has proved highly beneficial in simplifying and improving the work, and in diminishing the cost of production in our smitheries.

One example on this latter point will suffice. Formerly an anchor of 5 tons weight would cost £400; a much better anchor of a similar weight can now be made for £250. The reason is, that we now make the component parts above re-

* Stocks for anchors above 60 cwt. are made of wood.

ferred to ready for bringing together at a cost but little exceeding the price of the iron-bar used in the manufacture of Pering's and other anchors twenty years ago.

We have been favoured with many useful suggestions from time to time by various parties on the subject of anchor-making. Simplicity being now the high-road to success, it may be desirable to show the course pursued under my own directions, in order that where the plan of procedure differs, as it will be found to do in a greater or less degree in the several dock-yards, the course pursued in one yard, if it should appear better than in another, may be the means of securing a more general uniformity throughout the service.

In forming the "shanks" and "arms" of anchors three large "blooms" are provided in the first instance for each of these parts, according to the weight of the anchor required.

The united weight of the three blooms for the "shank" (if the shank is to be forged without resorting to the process of *piecing*) should be, say for a 50 cwt. anchor, 32 cwt.; the shank when finished will be three-fifths of the entire weight of the anchor, or 30 cwt.

For the "arms" the united weight of the three "blooms," say for a 50 cwt. anchor, should be 8 cwt.; each arm, when finished, will be one-seventh of the anchor.

Shanks and arms thus formed cannot fail under skilful treatment to be strong. The "blooms," being of large dimensions, are not likely to be injured by the "forgeman" in the process of welding.

Short scarfs will be found to be much more efficient in iron-work than long ones, from the simple fact that they give less trouble in welding, as the "hammer" or "Hercules" covers at every blow nearly the whole of the part requiring to be welded, one or both the scarf-ends being readily made good at one heat; whereas in *long* scarfs two and three heats will be required.

Sketches *a*, *b*, and *c* show the kind of scarfs usually adopted in the several Dock-yards of

Portsmouth (*a*),
Plymouth (*b*), and
Chatham (*c*):

c is the most simple and equally efficient.

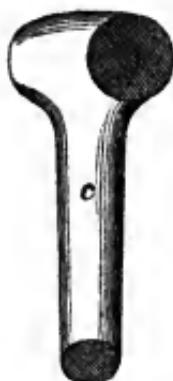
Scarf of the
Shank.
TYLER's plan.



Scarf of the Shank.
Proposed by Officers
of Devonport Yard.



Scarf of the Shank.
COTSELL's plan.



The following sketches, *d*, *e*, *f*, *g*, and *h*, show the several parts of the anchor in the state in which they pass from the hands of the forgeman at the steam hammer, to the anchor-smith, for completion.

For a 50 cwt. anchor, make the "Blooms" (Pl. 30, fig. 1) for the shank 32 cwt.; produce the "Shank" (Pl. 30, fig. 2), weighing 30 cwt.; proceed in like manner and produce the "Arms" (Pl. 30, fig. 3), weighing 7 cwt. each; then forge the "Palms" (Pl. 30, fig. 4), and the "Shackle" (Pl. 30, fig. 5), and then the "Stock" (Pl. 30, fig. 6), 10 cwt.: you have then all the parts.

In technical parlance these "forgings" are called "blanks," implying that they are not finished articles.

It cannot be too strongly urged upon the attention of anchor-smiths the propriety of adopting common short "scarfs" for bringing the parts together; and the plan of using *three* "blooms" only in forging the shanks and arms of anchors, is equally worthy of notice.

The holes in the squares of the shanks and the eyes in the shackles are all punched under the steam hammer by the forgeman.

In small anchors the "arm" and "palm" are forged in one piece at the steam hammer, and have been so made since 1846.

PLATE 30.

Sketches of the component parts of an Anchor in the state in which they are forged at the Steam Hammer, ready for the Anchorsmith.

Fig. 1.

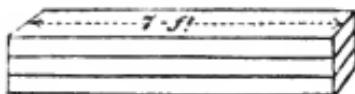


Fig. 2.



Fig. 3.



Fig. 4.



Fig. 5.

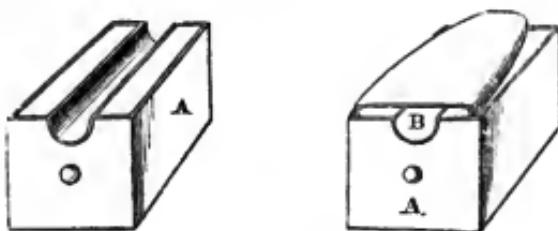


Fig. 6.



In August of that year, in reply to a letter received from the "Committee on Metals" relative to anchor-making, I wrote as follows :—

"The facilities afforded by the steam hammers induce me to propose that the 'arm and palm' should in future be forged in one piece, which can be done readily by providing a cast-iron block, or anvil, with a groove corresponding to the 'blade,' thus (A) :



"When the iron for the arm has been welded and partially shaped, make the part intended for the 'palm' and 'blade' welding-hot, place it on the grooved anvil, and, as is evident, as soon as it has received a few blows the groove becomes filled, and the remainder of the iron is deposited over the face of the anvil, and forms the palm, which can be flattened down to the exact thickness required (B)." (*Extract of Letter, dated Chatham Yard, 10th August, 1846.*)

Although this practice has been confined to small anchors, it will probably be extended when its utility is better known and suitable tools shall have been provided.

The question of tools, large and somewhat expensive as they must of necessity be for anchor "forgings," would furnish a weighty reason, were there no other, for the establishment of an anchor-factory. One well-furnished shop of this description would effect a saving beyond calculation. The well-known fact that the rapid and still increasing application of iron-work in every department of the service, particularly on board ship, has almost driven anchor-making out of the smitheries; and notwithstanding that there has recently been an increase in those establishments, it will be found necessary (should war continue) to still further augment the number of hands.

In sculpture, the last touches of the chisel, in the hands of a skilful artist, are those which give beauty; so the *finish* of the anchor will in like manner be regarded by the man who has given any attention to the points which contribute to perfection in *nipping* and *holding* properties. And as this is not

to be expected of the workmen, those who superintend the operations of anchor-making should constantly enforce it upon their attention.

In "shutting" the "arms" to the "shank" of the anchor the "heats" must be good and clean. It will be found desirable to have the heats rather over-hot to allow of the time necessary in getting the parts into contact with each other, particularly in the larger-sized anchors; and under no circumstances should the parts be permitted to be brought together if by any means their surfaces have any dirt, ashes, or other impurities about them; should such be allowed perfect welding is next to impossible.

TABLE A.

The proof-strains applied to anchors of the Admiralty plan; also to such of Rodger's, Porter's, and others as are received into "the Service."

Anchor.	Strain.	Anchor.	Strain.	Anchor.	Strain.	Anchor.	Strain.
Cwt.	Tons.	Cwt.	Tons.	Cwt.	Tons.	Cwt.	Tons.
100	67½	75	56½	50	42½	25	24½
99	66½	74	55½	49	41½	24	23½
98	66½	73	55½	48	41½	23	23½
97	66½	72	54½	47	40½	22	22½
96	65½	71	54½	46	39½	21	21½
95	65½	70	53½	45	39½	20	20½
94	65	69	53½	44	38½	19	19½
93	64½	68	52½	43	37½	18	19
92	64	67	52½	42	37½	17	18½
91	63½	66	51½	41	36½	16	17½
90	63½	65	51	40	35½	15	16½
89	62½	64	50½	39	35½	14	15½
88	62½	63	50	38	34½	13	14½
87	61½	62	49½	37	33½	12	13½
86	61½	61	48½	36	33½	11	12½
85	61	60	48½	35	32½	10	12
84	60½	59	47½	34	31½	9	11½
83	60	58	47½	33	30½	8	10½
82	59½	57	46½	32	30½	7	9½
81	59	56	46	31	29½	6	8½
80	58½	55	45½	30	28½	5	7½
79	58½	54	44½	29	27½	4	6½
78	57½	53	44½	28	27½	3	5½
77	57½	52	43½	27	26½	2	4½
76	56½	51	43	26	25½	1	3½

TABLE B.

The following Table shows the amount of *proof* strain applied to *chain cables*; the weight of the anchors to which they are severally appropriated; and the weight of the cable (with four swivels and eight shackles) per every 100 fathoms.

Size of Chain Cables.	Proof-strain in Tons.	Weight of the Anchor used with them.	Weight of Cable per 100 Fathoms.
Inches.	Tons.	Cwts.	Cwts. qrs. lbs.
2½	91½	100 to 88	240 0 0
2½	81½	87 " 75	216 3 0
2	72	74 " 63	192 0 0
1½	63½	62 " 52	168 3 0
1½	55½	51 " 42	147 0 0
1½	47½	41 " 35	126 3 0
1½	40½	34 " 28	108 0 0
1½	34	27 " 22	90 3 0
1½	28½	21 " 16	75 0 0
1½	22½	15 " 12	60 3 0
1	18	11 " 9	48 0 0
½	13½	8 " 6	36 3 0
¾	10½	5½ and 5	27 0 0
½	8½	4 " 3	22 2 21
½	7	2½ " 2	18 3 0
½	5½	—	15 0 20
½	4½	1½ " 1	12 0 0
½	3½	—	9 0 21

"TESTING."

The foregoing tables (A and B) show the amount of strain applied to all anchors and cables used in the British Royal Navy.

Prior to the introduction of the "Hydraulic Testing Machine" anchors were not generally subjected to any test of strength. They were "fire-proved;" that is, when finished, they were heated at the "crown" to a low-red heat, in order to discover any defects of workmanship. This test was not an efficient one; anchors that had been subjected to this ordeal often exhibited the worst possible description of fracture.

When the surface welding had been tolerably well executed, defects of workmanship that lay deeper could not be perceived even by the most practised eye; and, hence, the Old plan anchors were often broken, arising from defects lying far beneath the surface.

Anchors were sometimes *tried* by way of comparison, a purchase being brought upon them by means of capstans, but the amount of strain could not be registered; and, consequently, it only served to show which of two or more competing anchors was the stronger, and not how far they were equal to the service required of them.

The introduction of the "Hydraulic Testing Machine" furnished the means of *registering* the amount of the strain to which any article was subjected during the operation; and the behaviour or symptom during the process of *testing* is also exhibited, and, when accurately recorded, is of great value.

Whether any doubts had arisen as to the propriety of continuing to act strictly in accordance with the tests in the tables A and B, or whether a modification had been deemed expedient, I am unable to state; but we find that in 1845 a committee was appointed by the then Board of Admiralty, (called "The Committee on Metals,") to whom several questions were submitted for consideration and Report. Two of these bear peculiarly on this subject, and are worthy of notice.

Question 4. "What alterations, if any, should take place in proving chain cables and anchors, and experiments to be instituted to ascertain the effects on the metal of the various modes of testing the said cables and anchors?"

The next question is still more significant:—

Question 5. "To ascertain, at 'Woolwich and Portsmouth,' the amount of strain which has caused the breakage of chain cables and anchors, in the several cases in which they have broken in testing: and to investigate whether any variation in the mode of applying such strain may have tended to cause the breakage: in short, to examine into the whole of this subject so as to furnish satisfactory observations thereon."

The Committee report:—

"For the amount of strain which has caused the breakage of chain cables and anchors in the several cases in which they have broken in testing, (see Appendix,):

"In investigating this part of the subject, we have not found that the breakages have been caused by any variation in the mode of applying the

proof-strain. . . . We do not think it would be advisable to increase the proof-strain on either anchors or cables, believing it to be sufficiently severe.

"As regards anchors, we find that the proof-strain which is brought upon them seldom permanently alters their form, except to a very small extent. We, therefore, consider that the injury, if any, done to them is altogether inconsiderable, and that it is not expedient to make any reduction in the strain to which they are subject."

The proof-strain of chain cables and anchors the Committee saw no reason either to diminish or increase. Hence the tables, as now published, are the same as were acted upon at the date of the inquiry referred to.

Enough is elicited here to show that anchors were frequently broken whilst being tested; and, consequently, *at or under proof-strain!* Yet the Committee had not found that the breakages had been caused by any *variation in the mode of applying the proof-strain*. It will be of the highest practical advantage to ascertain the precise circumstances under which the breakages of chain cables and anchors have taken place in *testing*. The Report on this point refers to the Dock-yards of Woolwich and of Portsmouth. Now, although it may be very true that the *mode of applying* the proof strain in these Dock-yards do not vary, the circumstances under which the testing sometimes takes place may, and indeed do, differ materially in these *two yards*. In Portsmouth Yard, for example, during those periods of the year when the temperature ranges below 55° , fires are lighted and kept up in the testing-houses so as to raise the temperature to 55° , and it rarely, I believe, if ever it occurs, that any testing takes place when the temperature is below 55° : so much for Portsmouth. But at Woolwich Yard no regard is paid to this, nor are the testing-houses supplied with the means (as at Portsmouth) for raising the temperature.

There appears something so natural, practical, and common-sense in establishing a minimum temperature as a rule, that we wonder how it happens that the rule has not been enforced or adopted at every "testing-house" in the service.

Testing and temperature, or "testing" irrespective of any regard to temperature, resolves itself into a question of great practical importance.

Take an example: Anchors of 63 cwt. are subjected to a proof-strain of 50 tons; and this amount of strain has been deemed good; namely, the Committee did not think it advis-

able to increase or diminish the *proof-strain* on either anchors or cables; but that this proof-strain varies, is *increased or diminished*, will be self-evident.

Take a 63 cwt. anchor, subject it to the *proof-strain*—say 50 tons; the time of testing shall be July or August; the temperature is 75° in the shade. It passes the ordeal, is received into store, is issued and goes to sea; it ultimately turns out to be a very defective anchor. What then? it stood the test, and so the matter probably receives no further consideration.

Again: take a similar anchor, apply the proof-strain, say in the month of February, temperature 35° in the shade—50 tons still the *proof-strain*: the anchor breaks at $49\frac{1}{4}$ tons; it is “condemned” and “rejected”; it did not stand the proof-strain, and we trouble ourselves no further about it!

What impotent conclusions are these! It is obvious, at a glance, to any reflecting mind, that whilst the former anchor was not *tested* at all, the latter was most severely tested, and, what is more, probably unnecessarily destroyed.

Even taking the self-same anchor, we should be prepared to find that it would follow, as a natural consequence, that if tested under the favourable circumstances of temperature first indicated it would stand the test, and something considerably above it; whilst, on the contrary, if tested under the influence of a low state of temperature it would break probably several tons below proof-strain, and yet be a good anchor in respect of workmanship and materials; the evil of this state of things being, that a bad or indifferent anchor might pass, and a good one be destroyed.

Nor is it to be denied that even at Portsmouth, or elsewhere, where a minimum temperature for testing has been established, say at 55° , the anchors that are tested at 75° undergo *much less test*. Hence the conclusion obtains, that a graduated scale of *tests* is absolutely necessary, arranged specially with reference to the state of the temperature at the time of trial. Nothing is more sensitive to changes of temperature than iron; to test it, then, without regard to temperature is wrong—unskilful—wasteful! In what other way, except to highly favourable circumstances existing at the time of trial, are we to account for the defective character of some of the anchors that have broken in service, and yet are said to have stood “the test?” Even whilst I write the temperature stands at 80° in the shade; and I am prepared to say, that an

anchor of questionable workmanship would pass the prescribed ordeal of *proof-strain*, whilst under less favourable circumstances a much better made anchor would break. An alteration is therefore imperatively called for.

The whole question of "testing" appears to require revision. The state and condition of the "apparatus" is not always in sufficiently good working order to afford that satisfactory result which such operations demand.

"It is desirable that the *testing machines* be themselves tested, from time to time, to ascertain that they correctly register the strain brought upon them; or, in other words, that the accuracy of the machine be frequently examined." (Report of Committee on Metals: *vide* "Testing Houses.")

The pumps are sometimes found to refuse to perform their office, and when this is the case no explanation can ever be obtained as to the cause—a fact which of itself leaves room for suspicion; and in such matters every transaction and arrangement should be above suspicion.

In the breaking of the several anchors tried at Sheerness in 1852, and afterwards broken at Woolwich, it is curious to observe the difference in the amount of time occupied in the breaking of these anchors, and which tends to awaken some misgivings as to the working of the machinery.

Aylen's	was broken in	6 minutes	at $47\frac{1}{2}$	tons.
Lenox's	"	7	"	47
Isaacs'	"	10	"	62
Trotman's	"	18	"	$53\frac{1}{2}$
Rodger's	"	21	"	$73\frac{1}{2}$
Admiralty	"	26	"	$56\frac{1}{2}$
Honiball's	"	42	"	$75\frac{1}{2}$

Seeing that Aylen's anchor was broken in six minutes, whilst Honiball's was forty-two minutes in being broken, it is much to be regretted that the time in producing the "*first crack*," in which there is a close approximate similarity of strength, (Isaac's being excluded,) was not recorded, and which alone can add to the value of these statistics, particularly as the Committee report, page 8, paragraph 23—

"They have been guided by the strain on them at the *first crack*, after which they consider no dependence could be placed on an anchor."

The number of tons strain on the undermentioned anchors at the *first crack*:

Aylen's	:	:	:	:	:	44	tons strain.
Rodger's	:	:	:	:	:	45	" "

Lenox's	44½ tons strain.
Admiralty	48 " "
Trotman's	51½ " "

N.B.—Had the time occupied in bringing on these several strains, and the amount of the “deflection” in each case, been recorded, such data would have proved highly interesting and important: for it will be obvious, that if 40 tons strain were brought upon one anchor in, say, five minutes, and on another twenty-five minutes were occupied in putting on the same amount of strain, this difference must vitiate the value of such trials.

The Committee on metals also established a *form* for registering the tests, in which is a column for the state of *temperature* at the time of *testing*. There is reason to fear that little value is attached to this in some “Testing Houses,” for it would appear to be noted on some particular occasions, rather than as a general rule.

If, therefore, “testing” is to be worth the expense and trouble which it involves, nothing remains but to establish a graduated scale of “proof-strains,” having special reference to the state of the temperature *at the time of trial*, which should be faithfully and regularly recorded.

Taking “temperate” or 55° as the standard, 50 tons might at this point still be regarded as the *proof-strain* for an anchor of 63 cwt.; let the strain be gradually increased in proportion as the temperature rises above 55°, and decreased as it falls below 55°.

Unless something of this sort shall obtain at our “Testing Houses,” we cannot hope for any cessation to those glaring cases of bad workmanship which are constantly met with both in anchors and cables, although “branded” as having borne the ordeal of the prescribed tests, and which can only be accounted for by the fact of their having been tested under very favourable circumstances of temperature, or in some defect in the working of the testing-machines themselves.

Finally, I would wish some means adopted for securing the application of the several tests with great exactness, both as to the force employed and the time (as far as practicable) in every similar case; for example—Let the number of the pumps to be employed, the hands to work them, the number of strokes of the brakes per minute be no longer left to chance or caprice; but, like every other efficient check, be regulated by authority.

In most cases then, there would be some guarantee that all anchors and cables would not only have the test fairly applied, but that they would also be equally tested. Thus strangers to the minutiae of the machines themselves, might have the means of determining (by noting the time occupied in applying any amount of strain, together with the action or behaviour of the article being tested) whether there was any reason for supposing that the *test* had not been judiciously and fairly applied.

NOTE.—At Woolwich Yard, in the month of October or November, 1854, nine anchors were tested, of which number only *four* passed the ordeal. The probabilities are, that had the trials taken place under a high state of temperature, the whole might have passed into the service. Need we any further argument to show that testing should be regulated with reference to the alternations of temperature?

ANNEALING.

This process, as applied to anchors, must be discussed with great care, and can only be entertained by those whose opportunities have enabled them to approach it with the light of experience.

It has been recommended to anneal all iron-work.

The various uses to which iron-work is applied, the peculiar and varied forms and circumstances under which strains are brought upon it, will render it difficult to determine the *amount of annealing* to which it would be proper to subject it; indeed, the *process*, if indiscriminately applied to iron-work *in general*, would be productive of much mischief.

Many persons will not have before heard of “annealing.” Hence it is necessary to explain, that by annealing is meant the making any article of iron, after it has passed in a finished state from the hands of the smith, *red-hot*, so as to remove any brittleness which might have resulted from the hammering necessary to give the article an appearance of finish, generally regarded as a sign of good and careful workmanship. Let it be strictly understood that the “*cold-hammering*,” of which we sometimes hear reference made as a reason for some of the fractures which take place in anchors and other articles, is no longer practised.

Furnaces were recommended in 1845, of sufficient size to admit of our largest anchors being put into them to be made “*red-hot*,” and afterwards left there to cool, as the fire should

die away of its own accord ; and all iron-work was to be treated in a similar manner before being put to the use for which it had been made.

I objected to this, and I object still, although differing from many very esteemed friends with whom on most matters I could cordially agree. The great—the chief object being to obviate the breakages of anchors, and other large articles of iron—such, for example, as boats' davits,—

I believe that the remedy proposed would have given rise to a larger list of casualties than had previously existed, only of another kind.

I will take the two instances above referred to—anchors and boats' davits.

In the Report of the Committee on Metals, on the subject of *annealing*, they state it to be—

" . . . A process which appears to have the property of restoring to iron that quality of toughness which it may have lost in the act of being worked by cold hammering."

And they refer to a circumstance which happened at Portsmouth ; namely,

" The fracture of one of the paddle-box boat's davits of H. M. S. S. *Retribution*, which broke in the solid iron 4½ inches by 3½ inches, while getting the boat out ; the fracture was short, and the iron had the appearance of being brittle. . . . Probably, this would not have happened if the davit had been annealed."

Annealing, as recommended by the Committee, would restore "toughness" to the iron, and it is probable that the "davit" in question might have escaped fracture had it undergone the process referred to.

There is, however, a quality required in anchors and davits of a much higher value than *toughness*, and without which they are but sorry contrivances ; namely, "elasticity." An anchor or davit that had not this property or quality in its most extensive degree, would be disabled probably on the first occasion of its being brought into use.

The most that could be expected of these articles, if *annealed*, would be that they would *bend*, and not *break* under a strain ; but they are always subject to very heavy strains, particularly the anchor, so that it might be fairly inferred that no anchor would remain perfect for any length of time in use ; they

would have the character of *lead*, to a certain extent, rather than of iron—would be *flexible*, NOT *elastic*.

To this quality or property of *elasticity* we attach, and justly so, great importance. In testing an anchor, for example, whatever “deflection” ensues consequent upon the strain being applied, the “resisting power” of the anchor is judged of by the resumption of its original lines when the strain is taken off; and in proportion as one anchor is found to possess this property in a greater degree than another, so do we determine the degree of excellence. Upon this ground, notwithstanding that the process of *annealing* was so strongly insisted on, we were still to judge of the quality of anchors.

Steel is only more elastic than *iron* on account of the hammering which it undergoes in its manufacture, according to the uses for which it is intended to be applied: and it is to an approximate quality of *springiness* possessed by steel which we call *elasticity*, that any article of iron is capable of returning to its original form when relieved of any strain or force to which it has previously been subjected.

Some anchors return to their original lines with scarcely any appreciable variation, and such as do this are placed on the highest scale of excellence; but with the *annealing* process this property is lost, and an anchor that had been found thus eminently qualified for its work, if subjected to annealing in a furnace, would be bent at a much less amount of strain than “proof-strain,” and on the strain being taken off would remain *bent*, having had, to a certain extent, the character of *lead* imparted to it, which at once disqualifies it for constant and repeated resistance to strains such as an anchor, in use, has to bear. Take the case of a ship riding at anchor, pitching and tossing in a heavy sea-way, and with only some thirty fathoms of cable, (there seems to be a very general practice for riding at “short scope,” which cannot be too much condemned,) in the course of an hour the anchor will have been subjected, in all probability, to fifty strains greatly over proof-strain; will have “deflected” and “resumed” an equal number of times, which could not have been the case had the anchor been *annealed*.

The shank would have bent, the arm straightened, and the anchor rendered totally useless. To preserve the quality of elasticity in the anchor is above all things indispensable; and, hence, the only annealing required is that referred to elsewhere by roasting at the anchor-forgo with wood, which will be found

sufficient for the removal of undue brittleness, and yet preserve intact that *springiness* without which the anchor would be readily bent and distorted into all sorts of shapes.

The fracture of the boat's davit referred to by the Committee might have been the result of ignorance or mismanagement, such as I myself once witnessed, and which every one but those engaged saw must take place ; namely, in getting the boat in, in dock, some twenty hands were heaving away at the head-guy after the davit was hard home on the gully of the paddle-box, which, acting as a fulcrum, broke it off short about four inches above the gully. I am not wide of the mark in saying, that a very large per centage of fractures in iron-work, if traced to their true source, would prove to be the result of bungling or mismanagement.

At any rate, the paddle-box davits must not be annealed beyond that suggested above for the anchor, or it will bend under the weight of the boat, unless you greatly increase its size, which is not desirable.

There are so few articles of iron-work that do not require to be *elastic*,—stiff, rather than *tough*,—that I am induced to hope that under judicious supervision all the *annealing* necessary might be effected before the work leaves the hands of the smith, and that in an inexpensive, because speedy, way.

Of some 50,000 articles of iron-work manufactured yearly under my own superintendence, not fifty of them get broken, notwithstanding the rough handling and hard work to which they are subjected ; *anneal* them all in a furnace, and they would be constantly in the hands of the workmen for repair or rectification.

The number of fractures in iron-work, made under proper supervision, will be found so inconsiderable,—and even these cases, if traced to their proper source, would be found to be the result of accident, overstraining, or injudicious treatment,—that I dismiss the subject in the full conviction, that rightly viewed, apart from prejudice or self-interest, the matter is one of those which have been magnified beyond all reasonable limits.

Fractures you cannot altogether prevent any more than you can prescribe limits to the mind. They will occur occasionally so long as iron is susceptible to atmospheric and other external influences.

Whoever shall devote himself to ascertain the precise circumstances under which fractures in iron-work take place, and shall also be enabled to apply a remedy against them, will deserve well of the country which profits by his exertions.

STOCKS FOR ANCHORS.

GENERAL DIMENSIONS FOR FITTING STOCKS.

The length of the stocks, whether of wood or of iron, is equal to the length of the shank of the anchor measured from the outside of the "crown" to the extreme end of the "square."

The size of the stocks at the *middle*, when of *wood*, is one inch to the foot in length, at the ends half an inch; when of *iron*, half an inch to the foot in the middle, and about two-thirds of that size at the ends.

Iron stocks, when fitted in the Dock-yards, are 20 per cent. the weight of the anchor. Trotman's anchor-stocks are the same as those of the Admiralty plan.

"STOCKS" FOR ANCHORS.

Stocks are either of wood or of iron; formerly they were almost all of wood—they are now mostly of iron.

As already shown in the preceding pages of this work, several attempts have been made at various times, and by different parties, to construct an anchor which should require *no stock*. Hitherto, from some cause or other, these attempts have not been attended with that success which they deserved, for most assuredly the *stock* is an inconvenient appendage; yet without it the anchor is incomplete, and will not perform its office.

The part which the *stock* has to perform is, the throwing down or canting the anchor should it fall with the "arms" horizontally; then, as is evident, the stock will be vertical. The action of the ship will throw the stock horizontally, and the arms of the anchor will then be vertical, and should instantly enter the ground and stay the ship. *Stocks* are not often found to fail in this respect. On the whole, it may be said that they are very effective.

The rapid increase of *iron* stocks in place of wood is very remarkable, and bids fair to supersede the use of the latter material altogether. Whether the use of iron stocks for large anchors may be ultimately approved of remains to be seen. It might be carried too far. The *iron* stock being of greater specific gravity, and presenting much less resisting surface, during the passage of the anchor from the ship to the bottom, it encounters a more violent shock on meeting the ground than it would have done if fitted with a wooden stock.

There are many Naval officers of distinction who question the propriety of substituting iron for wood stocks. Iron stocks are not so unsightly as wood stocks, but the latter is not the less efficient.

Mr. Pering, in his "Treatise," page 72, says—

"The iron anchor-stock is a very bad substitute for wood; though much may be said against it, nothing but the plea of convenience can be adduced in its favour."

Lieut. Rodger, also, when introducing to public notice, upwards of twenty years ago, his "Patent Hollow-shanked Anchor," says—

"It is well known that *iron* stocks have a tendency to break the anchor, when let go with a *chain* on hard ground, and are only used for the convenience of stowage."

Yet we find Lieut. Rodger applying the *iron* stock to all anchors indiscriminately, although anchors are now used with *chains* almost universally!

In 1807 *iron* stocks were used in Her Majesty's service with anchors up to 15 cwt. only; in 1832, the practice had extended to anchors of 30 cwt.; in 1847, to 56 cwt.; and in 1852, to anchors of 60 cwt. This extensive application of *iron* stocks is chiefly owing to the employment of *war* steamers in the Royal Navy. In these vessels the wood stock has been found to be inconvenient.

Plate 31 shows the "stocks" at present in use, both wood and iron.

Fig. 1 is the Admiralty *wood* stock; is formed in the simplest manner of *two* pieces of timber; is readily converted from timber of small siding; may be shipped or fixed to the anchor without interfering with the shackle, and by means of the hoops can always be kept set up taut upon the square or shank of the anchor.

PLATE 31.

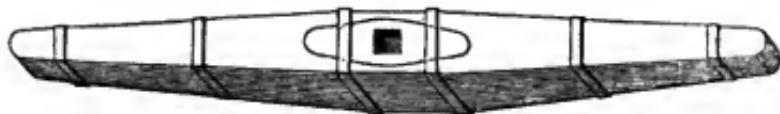
Fig. 1. ADMIRALTY *Wood Stock*.Fig. 2. Lieut. RODGER's *Wood Stock*.Fig. 3. ADMIRALTY *Iron Stock*.Fig. 4. Lieut. RODGER's *Iron Stock*.Fig. 5. COTSELL'S *Iron Stock*.

Fig. 2 is Lieut. Rodger's *wood stock*, is formed of one piece of timber, and consequently more costly than fig. 1. To fix it, the shackle of the anchor has to be removed to allow of its being shipped on over the end of the shank; in case of wear it cannot be set taut (as is done readily in the case of the Admiralty stock by simply driving the hoops up a little), to my mind it offers no advantages over the Admiralty stock, and has certainly some disadvantages.

Fig. 3 is the Admiralty *iron stock*, is exceedingly simple, is fixed to and detached from the anchor with ease; passes, as will be seen, through the shank up to the collar of the stock, and is secured on the other side by means of a fore-lock. An objection exists against this mode of fastening owing to its liability to be broken, the stock being often broken at the forelock-hole. In all other respects, so far as efficiency is concerned, nothing could be more simple, and it is cheaply manufactured.

Fig. 4 is Lieut. Rodger's *iron stock*, and, like his wood stock, has to be shipped on over the end of the shank, and necessitates, as before observed, the removal of the shackle of the anchor. The form of this stock and its weight, being generally 25 per cent. heavier than the Admiralty *iron stock*, not only add to the expense, but must also tend, agreeably to his own showing, in an increased degree to break the anchor, "*when let go with a chain on hard ground.*" Another serious objection must be made to the alteration of this stock as shown by him at "The Great Exhibition;" the middle being so formed that the section represents a semi-hexagon, with extremely sharp edges, to the great liability of injury to the cable should it get a turn round the stock thus (*a*):

This form, it would appear, has been given to the stock so as to enable it to present a resisting surface, and thus assist the anchor; a work of supererogation, if Lieut. Rodger's anchor really possesses those pre-eminent qualities ascribed to it by the patentee.

As the office of the anchor-stock is simply to cant the anchor when the arms are lying flat on the ground, the imposition of any further duty is foreign to its purpose, ill-advised, and highly objectionable.

With the present advance of mechanical knowledge we may yet hope to see an anchor of simple construction, and at the same time efficient, that shall require *no stock*. For my own

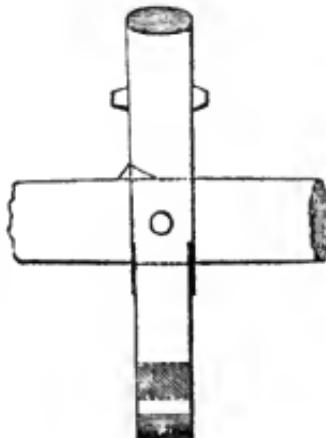
PLATE 32.

Sketch, showing the mode of fitting Cotsell's Iron Anchor Stock. Fig. 1 is the "Square" of the Shank, with the pin in the Stock-hole; fig. 2 is the reverse view of the Shank, with the Stock in place.

Fig. 1.



Fig. 2.



part I see no reason why this object may not be accomplished.

With a view to obviate the defect of the forelock-hole, which renders the anchor-stock liable to be broken off at that part, I had the honour to submit a plan for fitting it, which I feel sure would be an improvement in several respects.

By reference to Plate 31, fig. 5, it will be seen that the pin-hole is substituted for the forelock-hole; a pin and pellet (as used in chain cable shackles) are employed in lieu of the chain and forelock; a *stop* is wrought on the stock instead of the collar, and the pin-hole being housed midway in the square of the shank the stock obtains an equal amount of strength at both edges of the square; and, consequently, is more calculated to bear a shock without injury than with a forelock-hole at the critical point where it falls in the Admiralty stock.

Practically, this *iron* stock admits of being very easily "re-fitted" after it has become loose by wear; there being no collar or forelock-hole the part passing through the *shank* of the anchor is easily enlarged by a process well known among smiths, called "*Upsetting*," and which the collar and forelock-hole do not admit of to anything like the same extent.

Persons acquainted with the Lihou mode of fitting the pins in the pintles and braces on ships' rudders (as far as relates to the stop and slot) will readily understand how this stock is fitted—a sketch of which is given in Plate 32.

By permission of the Board of Admiralty an anchor of 23 cwt. has been so fitted, and awaits a trial.

The stocks proposed by Lenox, or that by Mitcheson (see Plates in second part of this work) are not to be preferred to those now in use in the Royal Navy; and for the reason already enumerated I would strongly urge the adoption generally of the Admiralty wood and iron stocks, or, as a substitute for the latter, that represented in Plate 31, fig. 5.

I have previously referred to the heavy iron stocks adopted by Lieut. Rodger, believing that the practice was not resorted to by any others.

Happening, however, to see a large number of anchors lying in a ship-agent's yard some little time back, not 100 miles from Mill-wall, I entered to take a survey.

I discovered several of Brown and Lenox's make, with immensely heavy stocks. Two or three were branded "Brown and Lenox's Improved." They were, however, but poor

PLATE 33.

Fig. 1.

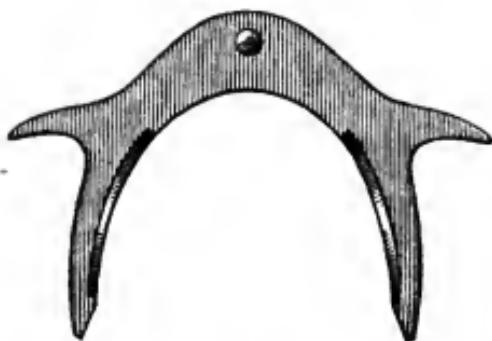


Fig. 1 represents PORTER's Flukes in their *present* form.

Fig. 2.



Fig. 2 represents Flukes of PORTER's Anchor, *altered as Cleopatra*.

The alterations are, setting the *flukes* to the proper curve; cutting off the *horns*; and forming the *lugs* to embrace the shank.

apologies for the Admiralty anchor, for which construction they were evidently intended. I looked in vain for any traces of the "Improved." Two examples are given:—

	Cwts.	qrs.	Ibs.
Anchor . . .	14	3	20
Stock . . .	4	2	16 or 30 per cent. the anchor.
Anchor . . .	25	1	0
Stock . . .	7	3	8 or 28 per cent. the anchor.

If Brown and Lenox consider that heavy iron stocks are an improvement, it is the property of Lieut. Rodger; and if they do not, then they are bound not to practise it.

PROPOSED ALTERATION OF PORTER'S ANCHORS.

It would appear that some of these anchors supplied to the Fleet recently employed in the Mediterranean having failed under circumstances which called forth official reports from the Admiral commanding-in-chief on that station, the Admiralty Board entertained the idea of re-converting them into other sorts. The following correspondence, alteration, trial, and report, took place consequent thereon.

[COPY.]

(1503.)

"Admiralty, 27th August, 1853.

"My Lords desire that you will order the Master Smith of Chatham Dock-yard to submit a plan for rendering Porter's anchors efficient by fixing a new set of flukes to the shanks in the same manner as the anchor made by the Master Smith, and supplied to the *Cleopatra*; stating whether the flukes of Porter's anchors can be altered so as to adapt them as fixtures to the shank.

"By command of their Lordships,

"W. A. B. HAMILTON.

"The Capt. Superintendent at Chatham."

[COPY.]

"31st August.

"To be copied and complied with.

"PETER RICHARDS, Capt. Supt."

[COPY.]

"Chatham Yard, 3rd Sept., 1853.

"Sir,—In obedience to your directions of the 31st ultimo, I herewith submit a plan for altering Porter's anchors, and rendering them efficient by fixing the flukes and shank in the same manner as the anchor made by me for the *Cleopatra*.

PLATE 34.

Fig. 3.



Fig. 4.



Fig. 5.



Fig. 6.



Figs. 3 and 4 represent PORTER's Shank in its *present* form.

Figs. 5 and 6 represent PORTER's Shank, *altered* as Cleopatra: viz., shortening the jaw, and raising shoulders to fill the *lugs* formed on the *flakes*.

"I respectfully beg to observe, that the *flukes* and the *shanks* of Porter's anchors are both equally adapted for the alterations alluded to, as shown in the accompanying drawings; and that if it be the wish of my Lords Commissioners of the Admiralty to preserve the *principle of portability*, the plan of alteration now submitted will effect that object; and the cost of the alteration will, I think, rarely exceed 12*s.* per cwt.

"Great care will, however, be necessary in carrying out these alterations, and in adapting the *shanks* to the required strength according to the weight of the anchors. Owing to the want of due proportions observable in some of these anchors, as pointed out in my letters of the 16th February, 1848, and 20th December, 1851, some of the *shanks* will have to be appropriated to anchors of a less weight.

"With the view to an *efficient* alteration, such as shall be satisfactory to my Lords Commissioners of the Admiralty (and in which I shall take a deep interest), I beg to submit that one of Porter's anchors, now in store in this Yard, may be altered for inspection and approval; and that it may be tested, not only as regards strength, but for its *nipping* and *holding* properties, so as to ascertain whether there be any necessity for removing their present *palms*, and substituting those of the Admiralty dimensions.

"I have the honour to be, Sir,

"Your very obedient, humble servant,

"GEORGE COTSELL, *Master Smith.*

"Peter Richards, C.B., Capt. Superintendent,

"&c., &c., &c.,

"H. M. Dock-yard, Chatham."

[COPY.]

"Woolwich Yard, 20th Dec., 1853.

"This anchor was tested on the 14th inst., in the presence of Mr. Cotsell: the proof-strain is 42 tons. The first arm and its connections stood the test with only $\frac{1}{2}$ inch permanent set; but on the second arm receiving a strain of $41\frac{1}{2}$ tons, one of the cheeks of the shank broke, and the other is cracked.

"On examination, it appears that there is a defect in the iron of the cheek which has sustained the greatest injury.

"JNO. McDONALD, *Master Attendant.*

"WM. RICE, *Master Shipwright.*

"CHAS. ATHERTON, *Chief Engineer.*"

(175.)

"Admiralty, 22nd Dec.

"Referred to Capt. Superintendent at Chatham for officers' information, and for any observations Mr. Cotsell may have to offer.

"R. DUNDAS."

"Chatham Yard, 23rd Dec.

"For the information of the officers, and for any observations Mr. Cotsell may have to offer.

"PETER RICHARDS, *Capt. Superintendent.*"

[COPY.]

Anchor, Porter's, altered by Mr. Cotsell; his Observations on the result of the trial of it at Woolwich.

"Chatham Yard, 28th Dec., 1853.

"Sir,—With reference to your memorandum of the 23rd inst., I beg most respectfully to observe, that the result of the trial of this anchor furnishes that kind of information which it was desirable to obtain at the outset of so extensive an undertaking as the alteration of 'the store' of Porter's anchors in the several yards necessarily involves, in order that the experience thereby gained may be turned to the best possible account in subsequent alterations.

"A knowledge of the fact that casualties are inseparably connected with alterations in general, led me (when honoured with your commands to submit a plan for the approval of their Lordships) to suggest that *one* of these anchors should, in the first instance, be altered, subject to trial and approval; with the view, that by its results their Lordships might be able to determine to proceed or not in the completion of the alteration of the anchors in store.

"Being desirous of effecting these alterations in an economical manner, all the *old* parts of this anchor were again brought into use; amongst others, the cheeks of the shank, one of which has broken off at a strain of $41\frac{1}{4}$ tons, the proof strain being 42 tons—the first arm having satisfactorily stood the *test*.

"The fracture of the cheek may be traced to the following causes:—

"The iron is less in size than if *new* ones had been made for the purpose; it is also slightly defective and very brittle, aggravated by the low state of the temperature at the time of trial, which deprived the iron of the property of *flexibility*.

"The old cheeks of Porter's anchor, it would appear, can only be safely used for anchors of much less weight.

"New cheeks, where necessary, will remedy the defect now exhibited, as they can be formed so as to insure greater strength in the mode of bringing them on to the shanks.

"In this anchor, Porter's old *palmes* are still retained, but of a modified form. In proceeding, however, with this alteration, we were led to the conclusion that the removal of the 'palms' would not increase the cost of alteration, whilst it would afford greater facilities for obtaining the due proportions of the parts. The Admiralty palm would be substituted.

"With the experience now obtained, I am enabled to state that the expense would not exceed that of the first alteration (13s. per cwt.), and that the object their Lordships have in view can be satisfactorily carried into execution.

"I have the honour to be, Sir,

"Your very obedient and humble servant,

"GEORGE COTSELL, Master Smith.

"Capt. Superintendent Peter Richards, C.B.,
&c., &c., &c."

This anchor is now (July, 1855,) in store at Chatham Yard.

Under the circumstances of this trial the failure, such as it was, is far from discouraging; but rather proves the practicability of converting these anchors as required.

NOTE.—Nothing has since been done in this matter. I would however observe, that a very important improvement in the junction of the parts which I have recently designed, will render the proposed alteration free from defects such as were then exhibited.

LONDON:

PRINTED BY JOHN WEALE, KING'S HEAD COURT, COUCH SQUARE.

005707069

Digitized by Google

A
CATALOGUE OF WORKS

IN

ARCHITECTURE (CIVIL AND NAVAL),
AGRICULTURE, CHEMISTRY, ELECTRICITY,
ENGINEERING (CIVIL, MILITARY, & MECHANICAL),
MATHEMATICS, MECHANICS, METALLURGY,

ETC. ETC.

AND

Books in General & School Literature.

INCLUDING

MR. WEALE'S

SERIES OF RUDIMENTARY WORKS,
SERIES OF EDUCATIONAL WORKS, AND
SERIES OF GREEK AND LATIN CLASSICS.

PUBLISHED BY

LOCKWOOD AND CO.

STATIONERS' HALL COURT, LONDON, E.C.

1859.

THE FAVOURITE FIRST FRENCH BOOK FOR A CHILD.
LA BAGATELLE:

Intended to introduce Children of five or six years old to some knowledge of the French Language. Revised by MADAME N. L. New and Cheaper Edition, much improved, and embellished with entirely new cuts. 18mo, price 2s. 6d., bound and lettered.

"Will be found to answer its intended purpose in every respect; and the volume can certainly lay claim to the merit of being produced with more than an average amount of care, so far as its typographical getting-up is concerned." — *Illustrated Times*.

"A very nice book to be placed in the hands of

children; likely to command their attention by its beautiful embellishments." — *Papers for the Schoolmaster*.

"A well-known little book, revised, improved, and adorned with some very pretty new pictures. It is, indeed, French made very easy for very little children." — *The School and the Teacher*.

Twelfth Edition, 8vo, 432 pages, reduced from 10s. 6d. to 7s. 6d. cloth.

LE BRETHON'S FRENCH GRAMMAR:

A GUIDE TO THE FRENCH LANGUAGE.

By J. J. P. LE BRETHON. Revised and corrected by L. SANDIER, Professor of Languages.

"A thorough practical book." — *Critic*.

"Of the many works that have come under our notice for teaching French, this excels them all." — *Hants Advertiser*.

"The great merit of this Grammar undoubtedly

is its clearness and simplicity of arrangement." — *Sun*.

"Deserves universal acceptance as the plainest, easiest, and completest Grammar ever published." — *Educational Gazette*.

Seventh Edition, considerably improved, with new plates substituted, 4to, 5s., cloth,

VOCABULAIRE SYMBOLIQUE ANGLO-FRANCAIS;

Pour les Élèves de tout Âge et de tout Degré; dans lequel les Mots les plus utiles sont enseignés par des Illustrations. Par L. C. RAGONOT, Professeur de la Langue Française.

A SYMBOLIC FRENCH AND ENGLISH VOCABULARY.

For Students of every Age, in all Classes; in which the most Useful and Common Words are taught by Illustrations. By L. C. RAGONOT, Professor of the French Language. The Illustrations comprise, embodied in the text, accurate representations of upwards of 850 different objects, besides nine whole-page copper-plates, beautifully executed, each conveying, through the eye, a large amount of instruction in the French Language.

"This work in the Anglo-French form having been extensively adopted, not only in Great Britain and on the Continent, but also in America, the publishers have determined to adapt it to other languages, and by producing it in a more portable form, to render it equally suitable to the Tourist and the General Scholar. The following is now ready,

8vo, 6s., red cloth, lettered,

SYMBOLISCHES ENGLISCH-DEUTSCHES WÖRTERBUCH:

THE

SYMBOLIC ANGLO-GERMAN VOCABULARY;

Adapted from the above work. Edited and Revised by FALCK LEBAHN, Ph.Dr., Author of "German in One Volume," "The German Self-Instructor," &c. With 850 woodcuts, and eight full page lithographic plates.

THE CHEAPEST SCHOOL ALGEBRA.

Seventh Edition, 12mo, 300 pages, reduced to 3s. 6d., bound,

NICHOLSON AND ROWBOTHAM'S PRACTICAL SYSTEM OF ALGEBRA.

DESIGNED FOR THE USE OF SCHOOLS AND PRIVATE STUDENTS.

THE

HISTORICAL LINES OF DR. GREY'S TECHNICAL MEMORY.

With various additions, chiefly as they apply to modern history. Arranged for general use. Sixth Edition, 1s., sewed.

LONDON, October, 1859.

A

CATALOGUE OF WORKS

IN

ARCHITECTURE, AGRICULTURE,
CHEMISTRY, ENGINEERING, MATHEMATICS, MECHANICS,
METALLURGY, &c. &c.

PUBLISHED BY

LOCKWOOD & CO.,
STATIONERS' HALL COURT, E.C.

COMPLETE LIBRARY OF THE MILITARY SCIENCES.

Three vols., royal 8vo, upwards of 500 Engravings and Woodcuts, in extra cloth boards,
and lettered, 4l. 10s.; or may be had in six separate parts, paper boards,

AIDE-MÉMOIRE TO THE MILITARY SCIENCES.

Framed from Contributions of Officers of the different Services, and edited by a Committee of the Corps of Royal Engineers. The work is now completed.

* * * This work is admirably adapted as a present to the young Military Student, and should find a place on the shelves of every Regimental Library. It is recommended to the notice of Volunteer Rifle or Artillery Corps.

ALBAN ON THE HIGH PRESSURE ENGINE.

In 8vo, with 28 fine plates, 16s. 6d. cloth,

THE HIGH PRESSURE STEAM ENGINE.

An Exposition of its Comparative Merits, and an Essay towards an Improved System of Construction, adapted especially to secure Safety and Economy.

By DR. ERNST ALBAN,
Practical Machine Maker, Plau, Mecklenberg.

TRANSLATED FROM THE GERMAN, WITH NOTES,
By WM. POLE, C.E., F.R.A.S., Assoc. Inst. C.E.

BUCK ON OBLIQUE BRIDGES.

Second Edition, imperial 8vo, price 12s. cloth,

A PRACTICAL AND THEORETICAL ESSAY ON OBLIQUE BRIDGES,

With 13 large Folding Plates.

By GEORGE WATSON BUCK, M. Inst. C.E.
Second Edition, corrected by W. H. BARLOW, M. Inst. C.E.

CARR'S SYNOPSIS.

Second Edition, in 18mo, cloth, 5s.

A SYNOPSIS OF PRACTICAL PHILOSOPHY.

ALPHABETICALLY ARRANGED,

containing a great variety of Theorems, Formulae, and Tables, from the most accurate and recent authorities, in various branches of Mathematics and Natural Philosophy : to which are subjoined small Tables of Logarithms. Designed as a Manual for Travellers, Architects, Surveyors, Engineers, Students, Naval Officers, and other Scientific Men.

By the Rev. JOHN CARR, M.A.,
Late Fellow of Trinity College, Cambridge.

* * * SIR JOHN MACNIEL, C.E., a good authority, recommends this work to his pupils and friends.

NICHOLSON'S CARPENTER'S GUIDE and PYNE'S RULES on DRAWING.

A New Edition, with 74 plates, 4to, price 1l. 1s. cloth,

THE CARPENTER'S NEW GUIDE ;

Or, Book of Lines for Carpenters. Comprising all the Elementary Principles essential for acquiring a knowledge of Carpentry, founded on the late PETER NICHOLSON'S standard work.

A New Edition, revised by ARTHUR ASHPITEL, Arch., F.S.A.;
TOGETHER WITH PRACTICAL RULES ON DRAWING,
By GEORGE PYNE, Artist.

DEMPSEY'S PRACTICAL RAILWAY ENGINEER.

In One large Vol. 4to, price 2l. 12s. 6d. cloth,

THE PRACTICAL RAILWAY ENGINEER.

A Concise Description of the Engineering and Mechanical Operations and Structures which are combined in the Formation of Railways for Public Traffic; embracing an Account of the Principal Works executed in the Construction of Railways to the Present Time; with Facts, Figures, and Data, intended to assist the Civil Engineer in designing and executing the important Details required for those Great Public Works.

By G. DRYSDALE DEMPSEY, Civil Engineer.

Fourth Edition, revised and greatly extended.

With 71 double quarto plates, 72 woodcuts, and Portrait of GEORGE STEPHENSON.

LIST OF PLATES.

1 Cuttings	33 Creosoting, screw-piling, &c.	53 Watering apparatus— (A.) Tanks
2—4 Earthworks, excavating	34 Permanent way and rails	54 Ditto, (B.) Details of pumps
5 Ditto, embanking	35 Ditto, chairs	55 Ditto, (C.) Details of engines
6 Ditto, waggons	36 Ditto, fish-joints, &c.	56 Ditto, (D.) Cranes
7 Drains under bridges	37 Ditto, fish-joint chairs	57 Hoisting machinery
8 Brick and stone culverts	38—9 Ditto, cast-iron sleepers, &c.	58 Ditto, details
9 Paved crossings	40 Ditto, Stephenson's, Brunel's, and Hennan's, Macneill's, and Dockray's	59 Traversing platform
10 Railway bridges, diagram	41 Ditto, Crossings	60 Ditto, details
11—14 Bridges, brick and stone	42 Ditto, ditto, details	61 Station-roof at King's Cross
15—16 Ditto, iron	43 Ditto, spring-crossings, &c.	62 Ditto, Liverpool
17—21 Ditto, timber	44 Ditto, turn-table	63 Ditto, Birmingham
22 Centres for bridges	45—6 Terminal station	64—5 Railway Carriages
23—27 "Pont de Montlouis"	47—9 Stations	66 Ditto, details
28 "Pont du Cher"	50 Goods stations	67—8 Railway Trucks and wheels
29 Suspension bridge	51 Polygonal engine-house	69 Iron and covered waggons
30 Box-girder bridge	52 Engine-house	70 Details of brakes
31 Trestle bridge and Chepstow bridge		71 Wheels and details
32 Details of Chepstow bridge		72 Portrait

BARLOW ON THE STRENGTH OF MATERIALS.*With Nine Illustrations, 8vo, 16s. cloth,***TREATISE ON THE STRENGTH OF TIMBER,
CAST IRON, MALLEABLE IRON,**

And other Materials; with Rules for Application in Architecture, the Construction of Suspension Bridges, Railways, &c.; and an Appendix on the Powers of Locomotive Engines on horizontal planes and gradients.

By PETER BARLOW, F.R.S.,
Hon. Member Inst. Civil Engineers, &c.

A New Edition by J. F. HEATHER, M.A., of the Royal Military Academy, Woolwich.

**WITH AN ESSAY ON THE EFFECTS PRODUCED BY CAUSING WEIGHTS TO TRAVEL
OVER ELASTIC BARS.**

By PROF. WILLIS, of Cambridge.

**GREGORY'S MATHEMATICS, BY LAW.**

Third Edition, in 8vo, with 13 Plates, very neatly half-bound in morocco, 12. 1s.

MATHEMATICS FOR PRACTICAL MEN.

Being a Common Place Book of Pure and Mixed Mathematics, designed chiefly for the use of Civil Engineers, Architects, and Surveyors.

By OLINTHUS GREGORY, LL.D., F.R.A.S.

Third Edition, revised and enlarged by HENRY LAW, Civil Engineer.

CONTENTS.**PART I.—PURE MATHEMATICS.**

Chapter I. Arithmetic.—Chap. II. Algebra.—Chap. III. Geometry.—Chap. IV. Mensuration.—Chap. V. Trigonometry.—Chap. VI. Conic Sections.—Chap. VII. Properties of Curves.

PART II.—MIXED MATHEMATICS.

Chapter I. Mechanics in General.—Chap. II. Statics.—Chap. III. Dynamics.—Chap. IV. Hydrostatics.—Chap. V. Hydrodynamics.—Chap. VI. Pneumatics.—Chap. VII. Mechanical agents.—Chap. VIII. Strength of Materials.—Appendix of Tables.

**A COMPLETE BODY OF HUSBANDRY, BY YOUATT.**

Tenth Edition, much enlarged, with numerous Engravings, 8vo, price 12s. cloth, lettered, gilt back.

THE COMPLETE GRAZIER,

AND FARMER'S AND CATTLE BREEDER'S ASSISTANT.

A Compendium of Husbandry: containing full instructions on the breeding, rearing, general management, and medical treatment of every kind of stock, the management of the dairy, and the arrangement of the farm offices, &c.; description of the newest and best agricultural implements; directions for the culture and management of grass land, and of the various natural and artificial grasses, draining, irrigation, warping, manures, &c.

By WILLIAM YOUATT, Esq., V.S.
Member of the Royal Agric. Soc. of England; Author of "The Horse," "Cattle," &c.

THE GREAT EASTERN AND IRON SHIPS IN GENERAL.

Second Edition, Atlas of Plates, with separate text, price 1L 5s.,

ON IRON SHIP-BUILDING.

With Practical Examples and Details, in Twenty-four Plates, including three of the Great Eastern, together with Text containing Descriptions, Explanations, and General Remarks, for the use of Ship-owners and Ship-builders.

By JOHN GRANTHAM, C.E.,
Consulting Engineer and Naval Architect, Liverpool.

* * * A work on the construction and build of Ships, by the application of Iron, has become now of the utmost importance, not only to Naval Architects, but to Engineers and Ship-owners. The present Work has been prepared, and the subjects drawn, in elevation, plan, and detail, to a scale useful for immediate practice, in a folio size, with figured dimensions, and a small Volume of text (which may be had separately, price 2s. 6d.)

DESCRIPTION OF PLATES.

- | | |
|--|--|
| 1 Hollow and bar keels, stem and stern posts.
2 Side frames, floorings, and bilge pieces.
3 Floorings continued—keelsons, deck beams, gunwales, and stringers.
4 Gunwales continued—lower decks, and orlop beams.
5 Angle-iron, T iron, Z iron, bulk iron, as rolled for iron ship-building.
6 Rivets, shown in section, natural size, flush and lapped joints, with single and double riveting.
7 Plating, three plans, bulkheads, and modes of securing them.
8 Iron masts, with longitudinal and transverse sections.
9 Sliding keel, water-hallast, moulding the frames in iron ship-building, levelling plates.
10 Longitudinal section, and half-breadth deck plans of large vessels, on reduced scale.
11 Midship sections of three vessels of different sizes.
12 Large vessel, showing details—Fore-end in section, and end view with stern posts, crutches, deck beams, &c.
13 Large vessel, showing details—After-end in sec- | tion, with end view, stern frame for screw, and rudder.
14 Large vessel, showing details—Midship section, half-breadth.
15 Machines for punching and shearing plates and angle-iron, and for bending plates; rivet heath.
16 Machines.—Garforth's riveting machine, drilling and counter sinking machine.
17 Air furnace for heating plates and angle-iron; various tools used in riveting and plating.
18 Gunwale, keel, and doorings; plan for sheathing iron ships with copper.
19 Illustrations of the magnetic condition of various iron ships.
20 Gray's floating compass and binnacle, with adjusting magnets.
21 Corroded iron bolt in frame of wooden ship; caulking joints of plates.
22 Great Eastern.—Longitudinal sections and breadth plans.
23 Great Eastern.—Midship section, with details.
24 Great Eastern.—Section in engine room, and paddle boxes. |
|--|--|

READY RECKONER, INCLUDING FRACTIONAL PARTS OF A POUND WEIGHT.

24mo, 1s. 6d. cloth, or 2s. strongly bound in leather,

THE INSTANT RECKONER.

Showing the Value of any Quantity of Goods, including Fractional Parts of a Pound Weight, at any price from One Farthing to Twenty Shillings: with an Introduction, embracing copious Notes of Coins, Weights, Measures, and other Commercial and Useful Information; and an Appendix, containing Tables of Interest, Salaries, Commission, &c.

SIMMS ON LEVELLING.

Fourth Edition, with 7 plates and numerous woodcuts, 8vo, 8s. 6d., cloth.

A TREATISE ON THE PRINCIPLES AND PRACTICE OF LEVELLING,

Showing its application to purposes of Railway and Civil Engineering, in the Construction of Roads, with Mr. TELFORD's Rules for the same.

By FREDERICK W. SIMMS, F.G.S., M. Inst. C.E.

Fourth Edition, with the addition of Mr. Law's Practical Examples for setting out Railway Curves, and Mr. Trautwine's Field Practice of Laying out Circular Curves.

**MOST USEFUL WORK FOR COUNTRY GENTLEMEN, FARMERS,
LAND AGENTS, &c.**

New Edition, with Additions and Corrections, price 4s., strongly bound,

THE LAND VALUER'S BEST ASSISTANT.

Being Tables, on a very much improved Plan, for Calculating the Value of Estates. To which are added, Tables for reducing Scotch, Irish, and Provincial Customary Acres to Statute Measure; also, Tables of Square Measure, and of the various Dimensions of an Acre in Perches and Yards, by which the Contents of any Plot of Ground may be ascertained without the expense of a regular Survey, Miscellaneous Information on English and Foreign Measures, Specific Gravities, &c.

By R. HUDSON, Civil Engineer.

"This new edition includes tables for ascertaining the value of leases for any term of years; and for showing how to lay out plots of ground of certain acres in forms, square, round, &c., with valuable rules for ascertaining the probable worth of standing timber to any amount; and is of incalculable value to the country gentleman and professional man."—*Farmer's Journal*.

INWOOD'S TABLES.

Seventeenth Edition. 12mo, cloth, 7s.,

TABLES FOR THE PURCHASING OF ESTATES,

Freehold, Copyhold, or Leasehold, Annuities, Advowsons, &c., and for the renewing of leases held under cathedral churches, colleges, or other corporate bodies, for terms of years certain, and for lives; also, for valuing reversionary estates, deferred annuities, next presentations, &c., the Five Tables of compound interest, the Government Table of Annuities, and an extension of SMART's Tables.

By WILLIAM INWOOD, Architect.

The Seventeenth Edition, with considerable additions, and new and valuable Tables of Logarithms for the more difficult computations of the Interest of Money, Discount, Annuities, &c., by Mons. PEDOR THOMAN, of the Société Crédit Mobiller, Paris.

NORMANDY'S COMMERCIAL HANDBOOK.

In post 8vo, illustrated with woodcuts, price 12s. 6d., handsomely bound in cloth,

THE

**COMMERCIAL HANDBOOK OF CHEMICAL
ANALYSIS;**

Or, Practical Instructions for the Determination of the Intrinsic or Commercial Value of Substances used in Manufactures, in Trades, and in the Arts.

By A. NORMANDY,

Author of "Practical Introduction to Rose's Chemistry," and Editor of Rose's "Treatise of Chemical Analysis."

"We recommend this book to the careful perusal of every one; it may be truly affirmed to be of universal interest, and we strongly recommend it to our readers as a guide, alike indispensable to the housewife as to the pharmaceutical practitioner."—*Medical Times*.

"A truly practical work. To place the unscientific person in a position to detect that which might ruin him in character and fortune, the present work will prove highly valuable. No one can peruse this treatise without feeling a desire to acquire further

and deeper knowledge of the exciting science of chemical analysis."—*Expositor*.

"The author has produced a volume of surpassing interest, in which he describes the character and properties of 400 different articles of commerce, the substances by which they are to frequently adulterated, and the means of their detection."—*Mining Journal*.

"The very best work on the subject the English press has yet produced."—*Mechanics' Magazine*.

NORMANDY'S CHEMICAL ATLAS AND DICTIONARIES.

The Atlas, oblong folio, cloth limp, 1L 1s., the Dictionaries, post 8vo, 7s. 6d., cloth; or, Atlas and Dictionaries together, 1L 8s. cloth.

THE CHEMICAL ATLAS;

Or, Tables, showing at a glance the Operations of Qualitative Analysis. With Practical Observations, and Copious Indices of Tests and Re-actions; accompanied by a Dictionary of Simple and of Compound Substances, indicating the Tests by which they may be identified; and a Dictionary of Re-agents, indicating their preparation for the Laboratory, the means of testing their purity, and their behaviour with Substances.

By A. NORMANDY,

Author of "The Commercial Handbook of Chemical Analysis," &c., &c., and Editor of H. Rose's "Treatise of Chemical Analysis."

"Tables such as these, like Maps and Charts, are more eloquent than the clearest prose statement. It is the most elaborate and perfect work of the kind that we are acquainted with."—*Mechanics' Magazine*.

"The work gives evidence of the author being perfect master of the task he has undertaken, and will no doubt occupy a place in the library of every chemical student and analyst."—*Mining Journal*.

"Several works on chemical analysis have for many years held a high position in the estimation of the scientific chemist. The work before us will be found in our opinion far more useful to the student of analysis, nay more, to the practitioner. The directions are more minute, and the number of cases introduced infinitely more varied. There is scarcely a possible case which the author has not provided for. From a careful examination we are able to say that any person possessed of a slight

knowledge of chemical manipulation, may, by means of the Atlas and Dictionaries soon make himself a proficient analyst. Everyone who studies the Atlas must be impressed with the magnitude of the author's labour, and the vast extent to which he has economised the time and trouble of those who avail themselves of his friendly assistance."—*The Chemist*.

"Normandy's Chemical Atlas' for comprehensiveness and completeness far surpasses anything of the kind hitherto published. I feel convinced that the student may with the aid of the Dictionaries, with which the Atlas is accompanied, successfully and alone undertake the examination of the most heterogeneous mixture, whether composed of organic or inorganic substances, or of both combined."—*Henry M. Nond, F.R.S., Lecturer on Chemistry at St. George's Hospital*.

By the same Author, crown 8vo, price 4s. 6d., cloth,

THE FARMER'S MANUAL OF AGRICULTURAL CHEMISTRY;

With Instructions respecting the Diseases of Cereals, and the Destruction of the Insects which are injurious to those plants. Illustrated by numerous woodcuts.

"This work will be found of incalculable value to the Farmer. We have perused it with much interest, and have no hesitation in recommending it to the notice of every farmer, who will find it an excellent guide in all questions of Agricultural Chemistry."—*Agricultural Magazine*.

"By far the best attempt to supply a treatise of a limited kind on the chemical analysis of the materials with which the agriculturist is concerned; the instructions are very satisfactory, and are accompanied by illustrative figures of the necessary apparatus."—*Aberdeen Journal*.

SPOONER ON SHEEP.

Second Edition. 12mo., 5s. cloth.

THE HISTORY, STRUCTURE, ECONOMY, AND DISEASES OF THE SHEEP.

In Three Parts. Illustrated with fine Engravings from Drawings by W. HARVEY, Esq.

By W. C. SPOONER, V.S.,

Member of the Council of the Royal College of Veterinary Surgeons; Honorary Associate of the Veterinary Medical Association; Author of "Treatise on the Influenza," and the "Structure, Diseases, &c., of the Foot and Leg of the Horse;" Editor of White's "Cattle Medicine," and White's "Compendium of the Veterinary Art."

"The name of Mr. Spooner, who is a distinguished member of his Profession, is a sufficient guarantee for the accuracy and usefulness of its contents. Farmers' clubs ought to add this work

to their libraries; and, as a work of reference, it ought to be in the possession of all Sheep Farmers."—*Gardeners' Chronicle*.

NOAD'S ELECTRICITY.

Fourth Edition, entirely re-written, in One Volume, illustrated by 500 woodcuts, 8vo, 11. 4s. cloth.

A MANUAL OF ELECTRICITY.

Including Galvanism, Magnetism, Dia-magnetism, Electro-Dynamics, Magno-Electricity, and the Electric Telegraph.

By HENRY M. NOAD, PH.D., F.C.S.,
Lecturer on Chemistry at St. George's Hospital.

Or in Two Parts :

Part I., ELECTRICITY and GALVANISM, 8vo, 16s. cloth.

Part II., MAGNETISM and the ELECTRIC TELEGRAPH, 8vo, 10s. 6d. cloth.

"This publication fully bears out its title of 'Manual.' It discusses in a satisfactory manner electricity, frictional and voltaic, thermo-electricity, and electro-physiology. To diffuse correct views of electrical science, to make known the laws by which this mysterious force is regulated, which is the intention of the author, is an important task."—*Athenaeum*.

"Dr. Noad's Manual, in some departments of which he has had the counsel and assistance of Mr. Faraday, Sir William Snow Harris, Professor Tyndall, and others, giving an additional sanction and interest to his work, is more than ever worthy of being received with favour by students and men of science. The style in which it is written is very exact and clear."—*Literary Gazette*.

"Dr. Noad's 'Manual of Electricity' has for several years ranked as one of the best popular treatises on this subject. By an excellent method of arrangement, and a clear and agreeable style, he introduces the student to a sound elementary knowledge of every department of electrical science."—*Atlas*.

"This is a work of great merit, and is creditable to the scientific attainments and philosophical research of the author. Too much praise cannot be bestowed on the patient labour and unwearyed application which were necessary to produce a work of such absorbing interest to the whole

trading and commercial community."—*Educational Gazette*.

"On the subject of electricity, it is a service second only to discovery, when one competent for the task undertakes to sift and reconstruct the old materials, and to bring together and incorporate them with all that is important in the new. Such a service Dr. Noad has performed in his 'Manual of Electricity.'"—*Chambers' Journal*.

"As a work of reference, this 'Manual' is particularly valuable, as the author has carefully recorded not only his authorities, but, when necessary, the words in which the writers have detailed their experiments and opinions."—*Mechanics' Magazine*.

"Among the numerous writers on the attractive and fascinating subject of electricity, the author of the present volume has occupied our best attention. It is worthy of a place in the library of every public institution, and we have no doubt it will be deservedly patronised by the scientific community."—*Mining Journal*.

"The commendations already bestowed in the pages of the *Lancet* on former editions of this work are more than ever merited by the present. The accounts given of electricity and galvanism are not only complete in a scientific sense, but, which is a rarer thing, are popular and interesting."—*Lancet*.

TREDGOLD ON THE STRENGTH OF IRON, &c.

Fourth Edition, in Two Vols., 8vo, 11. 4s., boards (either Volume may be had separately).

**A PRACTICAL ESSAY ON THE STRENGTH
OF CAST IRON AND OTHER METALS;**

Intended for the assistance of Engineers, Iron-Masters, Millwrights, Architects, Founders, Smiths, and others engaged in the construction of machines, buildings, &c.; containing Practical Rules, Tables, and examples founded on a series of new experiments; with an extensive table of the properties of materials.

By THOMAS TREDGOLD, Mem. Inst. C.E.,

Author of "Elementary Principles of Carpentry," "History of the Steam Engine," &c. Illustrated by several engravings and woodcuts. Fourth Edition, much improved and enlarged. By EATON HODGKINSON, F.R.S.

HODGKINSON'S RESEARCHES ON IRON.

* Vol. II. of the above consists of EXPERIMENTAL RESEARCHES on the STRENGTH and OTHER PROPERTIES of CAST IRON: with the development of new principles; calculations deduced from them; and inquiries applicable to rigid and tenacious bodies generally. By EATON HODGKINSON, F.R.S. With Plates and Diagrams, 8vo, 12s. boards.

ROGERS ON IRON METALLURGY.

With 20 carefully-prepared copper-plates. One Vol., 8vo, 12. 5s., cloth.

AN ELEMENTARY TREATISE ON IRON METALLURGY,

Up to the Manufacture of Puddle Bars, built upon the Atomic System of Philosophy ; the elements operated upon being estimated according to Dr. Wollaston's Hydrogen Scale of Equivalents ; comprising suggestions relative to important Improvements in the Manufacture of both Iron and Steel, and the conduct of Extensive Iron Works ; with Analytical Tables of Iron-making Materials.

By SAMUEL B. ROGERS, of Nant-y-Glo,

Inventor of Iron-Bottoms to Puddling-Furnaces, and of the present system of preparing Coke, in Double or Single Ovens.

"I do not hesitate to say that Mr. Rogers's work on Iron Metallurgy is, beyond comparison, the most complete combination of science and sound practice that has yet appeared on iron."—*David Mather.*

"A volume which ought to be at hand in every Iron Works in the kingdom, and in the possession of every Ironmaster."—*Wolverhampton Chronicle.*

"Mr. Rogers does not come before the public as

an untried theorist, for one of his inventions has been adopted generally throughout the Iron Manufactories of the world, and with immense advantage to Ironmasters."—*Bristol Times.*

"A remarkable book. Its author is, evidently, a man of practical experience, and of no mean scientific attainments, who has made the question on which he writes the business and study of his life."—*Staffordshire Advertiser.*

PYNE'S RULES FOR DRAWING.

In 4to, with 14 plates, in half cloth boards, 7s. 6d.

PRACTICAL RULES ON DRAWING,

FOR THE OPERATIVE BUILDER AND YOUNG STUDENT IN ARCHITECTURE.

By GEORGE PYNE,

Author of "A Rudimentary Treatise on Perspective for Beginners."

CONTENTS.

- | | |
|---|--|
| 1 Practical Rules on Drawing,—Outlines.
2 Ditto,—the Grecian and Roman Orders.
3 Practical Rules on Drawing,—Perspective. | 4 Practical Rules on Light and Shade.
5 Practical Rules on Colour.
&c. &c. |
|---|--|

DOBSON and GARBETT'S STUDENT'S GUIDE.

In One Vol., 8vo, extra cloth, 9s.

THE STUDENT'S GUIDE

TO THE PRACTICE OF DESIGNING, MEASURING, AND VALUING ARTIFICERS' WORKS;

Containing directions for taking Dimensions, abstracting the same, and bringing the Quantities into Bill ; with Tables of Constants, and copious memoranda for the Valuation of Labour and Materials in the respective trades of Bricklayer and Slater, Carpenter and Joiner, Sawyer, Stonemason, Plasterer, Smith and Ironmonger, Plumber, Painter and Glazier, Paper-hanger. With 43 plates and woodcuts. The Measuring, &c.,

Edited by EDWARD DOBSON, Architect and Surveyor.

Second Edition, with the Additions on Designs

By E. LACY GARBETT, Architect;

Together with Tables for Squaring and Cubing.

COTTAGES, VILLAS, AND COUNTRY HOUSES.*In 4to, 67 Plates, 1l. 1s. cloth,***DESIGNS AND EXAMPLES OF COTTAGES,
VILLAS, AND COUNTRY HOUSES.**

Being the Studies of Eminent Architects and Builders, consisting of plans, elevations, and perspective views; with approximate estimates of the cost of each.

**RYDE'S TEXT BOOK FOR ARCHITECTS, ENGINEERS, SURVEYORS, &c.***In One large thick Vol. 8vo, with numerous engravings, 1l. 8s.***A GENERAL TEXT BOOK,**

For the constant Use and Reference of Architects, Engineers, Surveyors, Solicitors, Auctioneers, Land Agents, and Stewards, in all their several and varied professional occupations; and for the assistance and guidance of country gentlemen and others engaged in the Transfer, Management, or Improvement of Landed Property, containing Theorems, Formulae, Rules, and Tables in Geometry, Mensuration, and Trigonometry; Land Measuring, Surveying, and Levelling; Railway and Hydraulic Engineering; Timber Measuring; the Valuation of Artificers' Work, Estates, Leaseholds, Lifeholds, Annuities, Tillages, Farming Stock, and Tenant Right; the Assessment of Parishes, Railways, Gas and Water Works; the Law of Dilapidations and Nuisances, Appraisements and Auctions, Landlord and Tenant, Agreements, and Leases. Together with Examples of Villas and Country Houses.

By EDWARD RYDE, Civil Engineer and Land Surveyor,
Author of several Professional Works.

To which are added several Chapters on Agriculture and Landed Property,

By Professor DONALDSON,
Author of several Works on Agriculture.

CONTENTS.

Chapter I. Arithmetic.—Chap. II. Plane and Solid Geometry.—Chap. III. Mensuration.—Chap. IV. Trigonometry.—Chap. V. Conic Sections.—Chap. VI. Land Measuring.—Chap. VII. Land Surveying.—Chap. VIII. Levelling.—Chap. IX. Plotting.—Chap. X. Computation of Areas.—Chap. XI. Copying Maps.—Chap. XII. Railway Surveying.—Chap. XIII. Colonial Surveying.—Chap. XIV. Hydrant Lines in connection with Drainage, Sewerage, and Water Supply.—Chap. XV. Timber Measuring.—Chap. XVI. Artificers' work.—Chap. XVII. Valua-

tion of Estates.—Chap. XVIII. Valuation of Tilage and Tenant Right.—Chap. XIX. Valuation of Parishes.—Chap. XX. Builders' Prices.—Chap. XXI. Dilapidations and Nuisances.—Chap. XXII. The Law relating to Appraisers and Auctioneers.—Chap. XXIII. Landlord and Tenant.—Chap. XXIV. Tables.—Chap. XXV. Stamp Laws.—Examples of Villas and Country Houses.

APPENDIX ON LANDED PROPERTY, by
Professor Donaldson, in Eight Chapters.

WHEELER'S AUCTIONEERS', &c., ASSISTANT.*2mo, cloth boards, 2s. 6d.***THE APPRAISER, AUCTIONEER, AND
HOUSE-AGENT'S POCKET ASSISTANT,**

For the valuation, purchase, and the renewing of Leases, Annuities, Reversions, and of Property generally; prices for inventories, with a Guide to determine the value of the interiors, fittings, furniture, &c.

By JOHN WHEELER, Valuer.

TEMPLETON'S WORKSHOP COMPANION. SIXTH EDITION.*In 12mo, price 5s., bound and lettered,***THE OPERATIVE MECHANIC'S WORKSHOP COMPANION,**

And THE SCIENTIFIC GENTLEMAN'S PRACTICAL ASSISTANT; comprising a great variety of the most useful Rules in Mechanical Science, divested of mathematical complexity; with numerous Tables of Practical Data and Calculated Results, for facilitating Mechanical and Commercial Transactions.

By W. TEMPLETON,

Author of "The Engineer's Common-Place Book," &c. &c.

Sixth edition, with eleven plates and the addition of Mechanical Tables for the use of Operative Smiths, Millwrights, Engineers, &c., and practical directions for the Smelting of Metallic Ores. To which also have been now added several useful and practical Rules in Hydraulics and Hydrodynamics, and an account of Dundas's Steam Hammer.

CONTENTS.

Geometry—Geometry applied to Mechanics—Decimal Arithmetic—Mensuration—Instrumental Arithmetic—Commercial Tables—Strength of Materials—Mechanic Powers—Continuous Circular	Motion—Friction—Properties of Water and Air—Steam Engine Boilers—Dundas's Steam Hammer—Logarithms.
---	--

THE BEST BUILDER'S PRICE BOOK.*Fourth Edition, in 12mo, cloth boards, lettered, 4s.,***WEALE'S BUILDER'S AND CONTRACTOR'S PRICE BOOK.**

Published Annually. Containing the latest prices for work in all branches of the Building Trade, with items numbered for easy reference; and an Appendix of Tables, Notes, and Memoranda, arranged to afford detailed information commonly required in preparing Estimates, &c., for Builders and Contractors of Public Works.

WIGHTWICK'S HINTS.

*With numerous Woodcuts. In 8vo, extra cloth, top edges gilt, 8s.,
HINTS TO YOUNG ARCHITECTS.*

Comprising Advice to those who, while yet at school, are destined to the profession; to such as, having passed their pupilage, are about to travel; and to those who, having completed their education, are about to practice: together with a Model Specification; involving a great variety of instructive and suggestive matter, calculated to facilitate their practical operations; and to direct them in their conduct as the responsible agents of their employers, and as the rightful judges of a contractor's duty.

By GEORGE WIGHTWICK, Architect,
Author of "The Palace of Architecture," &c., &c.

CONTENTS.

Preliminary hints to young ar.
chitects on the knowledge of
drawing
On serving his time
On travelling
His plate on the door
Orders, plan-drawings
On his taste, study of interiors
Interior arrangements
Warming and Ventilating
Housebuilding, stabling
Cottages and villas
Model Specification

General Classes	General Classes
Foundations	Foundations
Well	Well
Artificial Foundations	Artificial Foundations
Briekwork	Briekwork
Bubble masonry with briek migled	Bubble masonry with briek migled
Stone-cutting	Stone-cutting
" Grecian or Italian only	" Grecian or Italian only
" Gothic only	" Gothic only
Miscellaneous	Miscellaneous
Slating	Slating
Tiling	Tiling

Plaster and cement work	Plaster and cement work
Carpenters' work	Carpenters' work
Joiners' work	Joiners' work
Iron and metal work	Iron and metal work
Plombers' work	Plombers' work
Draughts	Draughts
Well-digging	Well-digging
Artificial levels, concrete, foun- dations, piling and planking, paving, vaulting, bell-hanging, plumbing, and building gene- rally.	Artificial levels, concrete, foun- dations, piling and planking, paving, vaulting, bell-hanging, plumbing, and building gene- rally.

TREDGOLD'S CARPENTRY. FOURTH EDITION.

*In One large Vol. 4to., 2l. 2s., in extra cloth.*THE ELEMENTARY PRINCIPLES OF
CARPENTRY ;

A Treatise on the pressure and equilibrium of timber framing, the resistance of timber, and the construction of floors, arches, bridges, roofs, uniting iron and stone with timber, &c., with practical rules and examples; to which is added, an essay on the nature and properties of timber, including the method of seasoning, and the causes and prevention of decay, with descriptions of the kinds of wood used in building; also numerous tables of the scantlings of timber for different purposes, the specific gravities of materials, &c.

By THOMAS TREDGOLD, Civil Engineer.

Illustrated by fifty-three Engravings, a portrait of the author, and several Woodcuts. Fourth Edition, corrected and considerably enlarged. With an Appendix, containing specimens of various ancient and modern roofs.

Edited by PETER BARLOW, F.R.S.

CONTENTS OF PLATES.

1 Equilibrium and pressure of beams.	27 Longitudinal section of ditto
2 Pressure of beams and centre of gravity	28 Truss of the roof of the Ducal riding house, Modena, double plate
3 Equilibrium and pressure of beams and framing	29 Truncated roof of ditto
4 Nailed flooring	30 Truss of roof of ditto.
5 to 9 Roofs	31 Section of the roof over the Exchange, Geneva, double
10 Roofs that have been erected	32 Foot of truss or roof over the new theatre at Aesona, ditto, Palazzo Vecchio, Florence; ditto, Cathedral, Florence, double.
11 Roof of the riding-house at Domes [Moscow]	33 Roofs of the Cathedral at Leghorn, double
12 Partitions and centre	34 Details of roof of Christ's Hospital, ditto
14 Centres for stone bridges; centre used for the bridge at Neuilly; for the Waterloo Bridge, and Conon Bridge	35 Ditto
15 Centres for stone bridges	36 Longitudinal section of St. Dunstan's Church, Fleet Street, double
16 Bridges	37 Roof and plan of ditto, ditto
17 Ditto, double plate	38 Details of ditto, ditto
18 Construction of bridges	39 Truss at the Thames Plate Glass Works; truss at the Princess's Theatre, Oxford Street; truss at a house in Berkeley Square
19 Bridges, double plate	40 Roof of iron and timber at Nottingham Water Works, treble plate
20 Bridges and joints	
21 Joints	
22 Joints and straps	
23 Roof and construction of the Pantheon, Oxford Street	
24 Ditto	
25 Section of Roof of Hall, Parkhurst Prison	
26 Section of roof of New Saloon, Academy of Arts, Florence	
	41 Cast-iron roof over the model-room of the Butterley Company, treble
	42 Cast-iron roof over the smithery of the ditto, ditto
	43 Iron and timber roof over the engine manufactory of the ditto, ditto
	44 Roof to King's College Chapel, Cambridge, ditto
	45 Ditto, transverse section
	46 Details, ditto
	47 Details, ditto
	48 Section of roof Great Northern Railway, London Terminus, Passenger Station
	49 Sections and details of ditto
	50 Great Northern Railway, London Terminus, Goods' Station, transverse section
	51 Iron Roof made for the Clyde Trustees for the Quay at Glasgow, with details
	52 Details of iron roof erected for Messrs. Joseph Whitworth & Co., Manchester
	53 Details, &c., of an iron roof, erected at the Galway Terminus

HANDY BOOK FOR ACTUARIES, BANKERS, INSURANCE OFFICES,
AND COMMERCIAL MEN IN GENERAL.*In 12mo, cloth, price 5s.*THEORY OF COMPOUND INTEREST AND
ANNUITIES,

With TABLES of LOGARITHMS for the more difficult computations of Interest, Discount, Annuities, &c., in all their applications and uses for Mercantile and State purposes, with a full and elaborate introduction.

By FEDOR THOMAN, of the Société Crédit Mobilier, Paris.

"A very powerful work, and the Author has a very remarkable command of his subject."—*Professor A. de Morgan.*

"No banker, merchant, tradesman, or man of business ought to be without Mr. Thomas's truly 'handy-book.'"—*Review.*

"The author of this 'handy-book' deserves our thanks for his successful attempt to extend the use of logarithms."—*Insurance Gazette.*

"We recommend it to the notice of actuaries and accountants."—*Athenaeum.*

WEALE'S ENGINEER'S POCKET BOOK.

With 8 copper plates, and numerous woodcuts, in roan tuck, 6s.

THE ENGINEER'S, ARCHITECT'S, AND CONTRACTOR'S POCKET BOOK.

Published annually. With DIARY of EVENTS and DATA connected with Engineering, Architecture, and the kindred Sciences, professionally and otherwise revised.

CONTENTS FOR 1860.

Alloys.	Almanack	Ganges (List of) and Weights of Galvanized Tinned Iron Sheets	Strength of Columns
Ballasting.	Barlow	Girders (Cast-iron)	Strength of Materials of Construction
Barrel Drains		Hawksley	Strength of Rolled T-Iron
Bassemeier on the Manufacture of Iron and Steel)		Heat (Effects of)	Stone, Preservation of
Boilers and Engines (Proportions of)		High Water at London Bridge	Stones
Boilers, Furnaces, and Chimneys		Howard	Tables of the Weight of Iron
Calendar		Hydraulics	Castings for Timber Roofs
Carpentry and Joinery		Hydrodynamics	of the Properties of Different Kinds of Timber
Cask and Malt Ganging		Institution of Civil Engineers (List of Members of)	of the Weights of Rails
Castings, sundry for Sewers, Gas-works, &c.		Institute of British Architects (List of Members of)	and Chairs
Cast-iron Columns and Girders		Iron Bar	of the Weight, Pressure, &c. of Materials, Cast-Iron, &c.
Chairs for Railways		— Roofs	of Weights of Copper, Tin-Plates, Copper-Pipes, Cocks for Coppers, Leaden Pipes
Chimneys, dimensions of		Knot Tables	for the Diameter of a Wheel of a Given Pitch
Circumference of Circles		Latitudes and Longitudes (&c. Log. of Sines, Cosines, Tangents,	of the Weights of a Lineal Foot of Flat Bar-Iron, of a Superficial Foot of Various Metals, &c.
Circular Arts (Tables of)		Marine Engines	of the Weight of a Lineal Foot of Cast-Iron Pipes
Circle, Cylinder, Sphere, &c.		Marine Screw Propulsion	of the Diameter of Solid or Cylinder of Cast-Iron, &c.
Coal Experiments; Economic Values of Coals.		Mariotier	of the Diameter and Thickness of Metal of Hollow Columns of Cast-Iron
Coking (evaporative Powers of Coal, and Results of)		Masonry	of Cast-Iron Stanchions
Columns, Posts, &c.		Measurment (Epitome of)	of Strength of Cast-Iron Bars
Copper Mines (Synopsis of) in Devon and Cornwall		Moriu's Experiments on Friction; on Hopes	of the Values of Earthwork
Cornwall Pumping-Engines		Natural Sines, &c.	of Weights and Measures
Current Coins		Neville, on Retaining Walls	of Natural Sines
On Buat		Notes to accompany the Abbreviated Table of Natural Sines	Teeth of Wheels
Earthwork		Peninsular and Oriental Steam Fleet	Telford's Memorandum Book
East London Waterworks		Probin [and Boilers	Thermometers
Eclipses		Proportions of Marine Engines	Timber for Carpentry and Joinery
Elastic Properties of Steam Elastic Curves, Frustrums, &c.		Proportional Sizes and Weights of Hexagon-heads and Nails for Bolts	Tredguld's Rule
Ephemerides of the Planets		Pumping Water by Steam Power	Waterworks
Fairbairn on the Mechanical Properties of Metals; on the tensile strength of wrought iron at various temperatures; Tubular Girder Bridges; Notes on Toughened Cast-Iron; on the Resistance of Tubes to Collapse		Rails	Weights of Copper, Brass, Steel, Hoop-Iron, &c.
Flooring		Rennie (G.); Messrs. Reunie	Weights and Measures
French and English Scales		Roofs	Weights of Balls
Friction		Ropes, Experiments of	Wicksteed Woods
Fuel on the American Railways and on English Railways		Sewers	
Gas Engineers' Calendar		Sleepers for Railways	
		Smith's Sewer. Sound	
		Specific Gravity of Gases	
		Square, Rectangle, Cube, &c.	
		Square and Round Bar-Iron	

MR. WEALE'S SERIES OF RUDIMENTARY, SCIENTIFIC, EDUCATIONAL, AND CLASSICAL WORKS,

At prices varying from 1s. to 2s. 6d.

Lists may be had on application to MESSRS. LOCKWOOD & CO.

** This excellent and extraordinarily cheap series of books, now comprising upwards of 150 different works, in almost every department of Science, Art, and Education, is strongly recommended to the notice of Mechanics' Institutions, Literary and Scientific Associations, Free Libraries, Colleges, Schools and Students generally, and also to Merchants, Shippers, &c.

CATALOGUE
OF
RUDIMENTARY, SCIENTIFIC, EDUCATIONAL, AND
CLASSICAL WORKS
FOR
COLLEGES, HIGH AND ORDINARY SCHOOLS,
AND SELF-INSTRUCTION.
ALSO FOR
MECHANICS' INSTITUTIONS, FREE LIBRARIES, &c., &c.

MR. WEALE'S
SERIES OF RUDIMENTARY WORKS
FOR THE USE OF BEGINNERS.

LONDON: JOHN WEALE, 59, HIGH HOLBORN.

WHOLESALE AGENTS, LOCKWOOD & CO., 7, STATIONERS' HALL COURT, E.C.

The several Series are amply illustrated, in demy 12mo., each neatly bound in cloth; and, for the convenience of purchasers, the subjects are published separately at the following prices:

1. CHEMISTRY, by Prof. Fownes, F.R.S., including Agricultural Chemistry, for the use of Farmers 1s.
2. NATURAL PHILOSOPHY, by Charles Tomlinson 1s
3. GEOLOGY, by Major-Gen. Portlock, F.R.S., &c. 1s. 6d.
- 4, 5. MINERALOGY, with Mr. Dana's additions, 2 vols. in 1 2s.
6. MECHANICS, by Charles Tomlinson 1s.
7. ELECTRICITY, by Sir William Snow Harris, F.R.S. 1s. 6d.
- 7.* ON GALVANISM; ANIMAL AND VOLTAIC ELECTRICITY; Treatise on the General Principles of Galvanic Science, by Sir W. Snow Harris, F.R.S. 1s. 6d.
- 8, 9, 10. MAGNETISM, Concise Exposition of, by the same, 3 vols. in 1. 3s. 6d.
- 11, 11* ELECTRIC TELEGRAPH, History of the, by E. Highton, C.E. . . . 2s.
12. PNEUMATICS, by Charles Tomlinson 1s.
- 13, 14, 15, 15.* CIVIL ENGINEERING, by Henry Law, C.E., 3 vols.; and Supplement by G. R. Burnell, C.E., in 1 vol. 4s. 6d.

16. ARCHITECTURE, Orders of, by W. H. Leeds	1s.
17. ARCHITECTURE, Styles of, by T. Bury, Architect	1s. 6d.
18, 19. ARCHITECTURE, Principles of Design in, by E. L. Garbett, 2 vols. in 1: 2s.	
20, 21. PERSPECTIVE, by G. Pyne, 2 vols in 1	2s.
22. BUILDING, Art of, by E. Dobson, C.E.	1s.
23, 24. BRICK-MAKING, TILE-MAKING, &c., Art of, by the same, 2 vols. in 1	2s.
25, 26. MASONRY AND STONE-CUTTING, Art of, by the same, with illustrations of the preceding, 2 vols. in 1, by the same	2s.
27, 28. PAINTING, Art of, or a GRAMMAR OF COLOURING, by George Field, 2 vols. in 1	2s.
29. DRAINING DISTRICTS AND LANDS, Art of, by G. D. Dempsey, C.E.	1s.
30. DRAINING AND SEWAGE OF TOWNS AND BUILDINGS, Art of, by the same	1s. 6d.
31. WELL-SINKING AND BORING, Art of, by G. R. Burnell, C.E.	1s.
32. USE OF INSTRUMENTS, Art of the, by J. F. Heather, M.A.	1s.
33. CONSTRUCTING CRANES, Art of, by J. Glynn, F.R.S., C.E.	1s.
34. STEAM ENGINE, Treatise on the, by Dr. Lardner	1s.
35. BLASTING ROCKS AND QUARRYING, AND ON STONE, Art of, by Lieut.-Gen. Sir J. Burgoine, Bart., G.C.B., R.E.	1s.
36, 37, 38, 39. DICTIONARY OF TERMS used, by Architects, Builders, Civil and Mechanical Engineers, Surveyors, Artists, Ship-builders, &c., 4 vols. in 1	4s.
40. GLASS STAINING, Art of, by Dr. M. A. Gessert	1s.
41. PAINTING ON GLASS, Essay on, by E. O. Fromberg	1s.
42. COTTAGE BUILDING, Treatise on	1s.
43. TUBULAR AND GIRDER BRIDGES, and others, Treatise on, more particularly describing the Britannia and Conway Bridges	1s.
44. FOUNDATIONS, &c., Treatise on, by E. Dobson, C.E.	1s.
45. LIMES, CEMENTS, MORTARS, CONCRETE, MASTICS, &c., by G. R. Burnell, C.E.	1s.
46. CONSTRUCTING AND REPAIRING COMMON ROADS, by H. Law, C.E.	1s.
47, 48, 49. CONSTRUCTION AND ILLUMINATION OF LIGHTHOUSES, by Alan Stevenson, C.E., 3 vols. in 1	3s.
50. LAW OF CONTRACTS FOR WORKS AND SERVICES, by David Gibbons	1s.
51, 52, 53. NAVAL ARCHITECTURE, Principles of the Science, by J. Peake, N.A., 3 vols. in 1	3s.
53*. LAYING OFF SHIPS, being an introduction to the Mould Loft of Ship Building, by James Peake, N.A. <i>in the press</i>	1s. 6d.
53**. ATLAS of large Plates to ditto ditto	1s. 6d.
54. MASTING, MAST-MAKING, AND RIGGING OF SHIPS, by R. Kipping, N.A.	1s. 6d.
54*. IRON SHIP BUILDING, by John Grantham, N.A. and C.E.	2s. 6d.
55, 56. NAVIGATION, Treatise on; THE SAILOR'S SEA-BOOK.—How to keep the Log and work it off—Latitude and Longitude—Great Circle Sailing—Law of Storms and Variable Winds; and an explanation of Terms used, with coloured illustrations of Flags	2s.
57, 58. WARMING AND VENTILATION, by Charles Tomlinson, 2 vols. in 1	2s.
59. STEAM BOILERS, by R. Armstrong, C.E.	1s.

60, 61. LAND AND ENGINEERING SURVEYING, by T. Baker, C.E., 2 vols. in 1:	2s.
62. RAILWAY DETAILS, by Sir M. Stephenson, Vol. I.	1s.
62*. RAILWAY WORKING IN GREAT BRITAIN, Statistical Details, Table of Capital and Dividends, Revenue Accounts, Signals, &c., &c., by E. D. Chattaway. Vol. II.	1s.
63, 64, 65. AGRICULTURAL BUILDINGS, the Construction of, on Motive Powers, and the Machinery of the Steading; and on Agricultural Field Engines, Machines, and Implements, by G. H. Andrews, 3 vols. in 1	3s.
66. CLAY LANDS AND LOAMY SOILS, by Prof. Donaldson, A.E.	3s.
67, 68. CLOCK AND WATCH-MAKING, AND ON CHURCH CLOCKS, by E. B. Denison, M.A., 2 vols. in 1	2s.
69, 70. MUSIC, Practical Treatise on, by C. C. Speneer, 2 vols. in 1	2s.
71. PIANO-FORTE, Instruction for Playing the, by the same	1s.
72. 73, 74, 75, 75*. RECENT FOSSIL SHELLS (A Manual of the Mollusca), by Samuel P. Woodward, and illustrations, 4 vols. in 1, Supplement 5s. 6d.	
76, 77. DESCRIPTIVE GEOMETRY, by J. F. Heather, M.A., 2 vols. in 1	2s.
77*. ECONOMY OF FUEL, by T. S. Prideaux	1s.
78, 79. STEAM AS APPLIED TO GÉNÉRAL PURPOSES AND LOCOMOTIVE ENGINES, by J. Sewell, C.E., 2 vols. in 1	2s.
78*. LOCOMOTIVE ENGINE, by G. D. Dempsey, C.E.	1s. 6d.
79*. ATLAS OF PLATES to the above	4s. 6d.
79**. ON PHOTOGRAPHY, the Composition and Properties of the Chemical Substances used, by Dr. H. Halleur	1s.
80, 81. MARINE ENGINES, AND ON THE SCREW, &c., by R. Murray, C.E. 2 vols. in 1	2s. 6d.
80*, 81*. EMBRANKING LANDS FROM THE SEA, by John Wiggins, F.G.S., 2 vols. in 1	2s.
82, 82*. POWER OF WATER, AS APPLIED TO DRIVE FLOUR MILLS, by Joseph Glynn, F.R.S., C.E.	2s.
83. BOOK-KEEPING, by James Haddon, M.A.	1s.
82**, 83*, 83* COAL GAS, on the Manufacture and Distribution of, by Samuel Hughes, C.E.	3s.
82***. WATER WORKS FOR THE SUPPLY OF CITIES AND TOWNS. Works which have been executed for procuring Supplies by means of Drainage Areas and by Pumping from Wells, by Samuel Hughes, C.E. 3s.	
83**. CONSTRUCTION OF DOOR LOCKS, with illustrations	1s. 6d.
83 (bis). FORMS OF SHIPS AND BOATS, by W. Bland, of Hartlip	1s.
84. ARITHMETIC, and numerous Examples, by Prof. J. R. Young	1s. 6d.
84*. KEY to the above, by the same	1s. 6d.
85. EQUATIONAL ARITHMETIC, Questions of Interest, Annuities, &c., by W. Hipsley	1s.
85*. SUPPLEMENTARY VOLUME, Tables for the Calculation of Simple Interest, with Logarithms for Compound Interest and Annuities, &c., &c., by W. Hipsley	1s.
86, 87. ALGEBRA, by James Haddon, M.A., 2 vols. in 1	2s.
86*, 87*. ELEMENTS OF ALGEBRA, Key to the, by Prof. Young	1s. 6d.
88, 89. DESCRIPTIVE GEOMETRY, by Henry Law, C.E., 2 vols. in 1	2s.
90. GEOMETRY, ANALYTICAL, by James Hann	1s.
91, 92. PLANE AND SPHERICAL TRIGONOMETRY, by the same, 2 vols. in 1	2s.

93. MENSURATION, by T. Baker, C.E.	1s.
94, 95. LOGARITHMS, Tables for facilitating Astronomical, Nautical, Trigonometrical, and Logarithmic Calculations, by H. Law, C.E., 2 vols. in 1	2s.
96. POPULAR ASTRONOMY, by the Rev. Robert Main, M.R.A.S.	1s.
97. STATICS AND DYNAMICS, by T. Baker, C.E.	1s.
98, 98*. MECHANISM AND PRACTICAL CONSTRUCTION OF MACHINES, On Tools and Machines, by James Nasmyth, C.E.	2s. 6d.
99, 100. NAUTICAL ASTRONOMY AND NAVIGATION, by Prof. Young. 2 vols. in 1	2s.
100*. NAVIGATION TABLES, compiled for practical use with the above	1s. 6d.
101. DIFFERENTIAL CALCULUS, by Mr. Woolhouse, F.R.A.S.	1s.
101*. WEIGHTS AND MEASURES OF ALL NATIONS; Weights, Coins, and the various Divisions of Time, with the principles which determine Rates of Exchange, by Mr. Woolhouse, F.R.A.S.	1s. 6d.
102. INTEGRAL CALCULUS, by H. Cox, M.A.	1s.
103. INTEGRAL CALCULUS, Examples of, by James Hann	1s.
104. DIFFERENTIAL CALCULUS, Examples of, by J. Haddon, M.A.	1s.
105. ALGEBRA, GEOMETRY, AND TRIGONOMETRY, Mnemonical Lessons, by the Rev. T. Penyngton Kirkman, M.A.	1s. 6d.
106. SHIPS' ANCHORS FOR ALL SERVICES, by George Cotsell, upwards of 100 illustrations	1s. 6d.
107. METROPOLITAN BUILDINGS ACT, in present operation, with Notes	2s. 6d.
108. METROPOLITAN LOCAL MANAGEMENT ACTS	1s. 6d.
109. LIMITED LIABILITY AND PARTNERSHIP ACTS	1s. 6d.
110. SIX RECENT LEGISLATIVE ENACTMENTS, for Contractors, Merchants, and Tradesmen	1s.
111. NUISANCES REMOVAL AND DISEASE PREVENTION ACT	1s.
<hr/>	
112. DOMESTIC MEDICINE, by M. Raspail	1s. 6d.
113. USE OF FIELD ARTILLERY ON SERVICE, by Capt. H. Maxwell, B.A. 1s. 6d.	
<hr/>	
114. ON MACHINERY: The Machine in its Elements, Practice, and Purpose, by Chas. D. Abel, C.E., wood-cuts	1s. 6d.
115. ATLAS OF PLATES OF SEVERAL KINDS OF MACHINES, 14 plates large 4to.	4s. 6d.
116. RUDIMENTARY TREATISE ON ACOUSTICS: The Distribution of Sound, by G. R. Burnell, C.E.	1s. 6d.
117. ON CANAL ENGINEERING AND ARTIFICIAL NAVIGATION, by G. R. Burnell, C.E.	1s. 6d.
118, 119. ON THE CIVIL ENGINEERING OF NORTH AMERICA, by D. Stevenson, C.E., 2 vols. in 1	3s.
120. ON HYDRAULIC ENGINEERING, by G. R. Burnell, C.E., 2 vols. in 1 .	3s.
121. ON RIVER ENGINEERING AND THE CONSTRUCTION OF DOCKS AND HARBOURS, by G. R. Burnell, C.E. Vol. III.	2s.
122. ON FLUIDS, by G. R. Burnell, C.E.	1s.
123. ON CARPENTRY AND JOINERY, founded on Dr. Robison's Work, with wood-cuts	1s. 6d.
123*. ATLAS TO DITTO	4s. 6d.

124. ON ROOFS FOR PUBLIC AND PRIVATE BUILDINGS, founded on Dr. Robison's Work 1s. 6d.
 124*. RECENTLY CONSTRUCTED IRON ROOFS, Atlas of plates 4s. 6d.
 125. ON THE COMBUSTION OF COAL AND THE PREVENTION OF SMOKE, Chemically and Practically Considered, by Chas. Wye Williams, M.I.C.E. { The 2 vols. } 3s.
 126. Illustrations to ditto { in 1. } 3s.
 127. RUDIMENTARY AND PRACTICAL INSTRUCTIONS IN THE ART OF ARCHITECTURAL MODELLING, with illustrations for the Practical Application of the Art, by J. A. Richardson, Arch. 1s. 6d.
 128. THE TEN BOOKS OF M. VITRUVIUS ON CIVIL, MILITARY, AND NAVAL ARCHITECTURE,* translated by Joseph Gwilt, Arch., 2 vols. in 1, *in the press* 2s. 6d.
 129. ATLAS OF ILLUSTRATIVE PLATES TO DITTO, in 4to, with the Vignettes, designed by Joseph Gandy, *in the press* 4s. 6d.
 130. INTRODUCTION TO THE STUDY AND THE BEAUTY OF GRECIAN ARCHITECTURE, by the Right Hon. the Earl of Aberdeen, &c., &c., &c., *in the press* 1s.
-

MR. WEALE'S NEW SERIES OF EDUCATIONAL WORKS.

- 1, 2, 3, 4. CONSTITUTIONAL HISTORY OF ENGLAND, by W. D. Hamilton 4s.
 5, 6. OUTLINES OF THE HISTORY OF GREECE, by the same, 2 vols. 2s. 6d.
 7, 8. OUTLINE OF THE HISTORY OF ROME, by the same, 2 vols. 2s. 6d.
 9, 10. CHRONOLOGY OF CIVIL AND ECCLESIASTICAL HISTORY, LITERATURE, ART, AND CIVILISATION, from the earliest period to the present, 2 vols. 2s. 6d.
 11. GRAMMAR OF THE ENGLISH LANGUAGE, by Hyde Clarke, D.C.L. 1s.
 11*. HAND BOOK OF COMPARATIVE PHILOLOGY, by the same 1s.
 12, 13. DICTIONARY OF THE ENGLISH LANGUAGE. A new Dictionary of the English Tongue, as spoken and written, above 100,000 words, or 50,000 more than in any existing work, by the same, 3 vols. in 1 3s. 6d.
 14. GRAMMAR OF THE GREEK LANGUAGE, by H. C. Hamilton 1s.
 15, 16. DICTIONARY OF THE GREEK AND ENGLISH LANGUAGES, by H. R. Hamilton, 2 vols. in 1 2s.
 17, 18. ENGLISH AND GREEK LANGUAGES, by the same, 2 vols. in 1 2s.
 19. GRAMMAR OF THE LATIN LANGUAGE, by the Rev. T. Goodwin, A.B. 1s.
 20, 21. DICTIONARY OF THE LATIN AND ENGLISH LANGUAGES, by the same. Vol. I. 2s.
 22, 23. ENGLISH AND LATIN LANGUAGES, by the same. Vol. II. 1s. 6d.
 24. GRAMMAR OF THE FRENCH LANGUAGE 1s.

* This work, translated by a scholar and an architect, was originally published at 3s. It bears the highest reputation, and being now for the first time issued in this Series, the student and the scholar will receive it as a boon from the gifted translator.

25. DICTIONARY OF THE FRENCH AND ENGLISH LANGUAGES, by A. Elwes. Vol. I.	1s.
26. ————— ENGLISH AND FRENCH LANGUAGES, by the same. Vol. II.	1s. 6d.
27. GRAMMAR OF THE ITALIAN LANGUAGE, by the same	1s.
28, 29. DICTIONARY OF THE ITALIAN, ENGLISH, AND FRENCH LANGUAGES, by the same. Vol. I.	2s.
30, 31. ————— ENGLISH, ITALIAN, AND FRENCH LANGUAGES, by the same. Vol. II.	2s.
32, 33. ————— FRENCH, ITALIAN, AND ENGLISH LANGUAGES, by the same. Vol. III.	2s.
34. GRAMMAR OF THE SPANISH LANGUAGE, by the same	1s.
35, 36, 37, 38. DICTIONARY OF THE SPANISH AND ENGLISH LANGUAGES, by the same, 4 vols. in 1	4s.
39. GRAMMAR OF THE GERMAN LANGUAGE	1s.
40. CLASSICAL GERMAN READER, from the best authors	1s.
41, 42, 43. DICTIONARIES OF THE ENGLISH, GERMAN, AND FRENCH LAN- GUAGES, by N. E. Hamilton, 3 vols., separately 1s. each	3s.
44, 45. DICTIONARY OF THE HEBREW AND ENGLISH LANGUAGES, contain- ing the Biblical and Rabbinical words, 2 vols. (together with the Grammar, which may be had separately for 1s.) by Dr. Bresslau, Hebrew Professor	7s.
46. ————— ENGLISH AND HEBREW LANGUAGES. Vol. III. to complete	3s.
47. FRENCH AND ENGLISH PHRASE BOOK	1s.

THE SERIES OF EDUCATIONAL WORKS

*Are on sale in two kinds of binding; the one for use in Colleges and Schools
and the other for the Library.*

HAMILTON'S OUTLINES OF THE HISTORY OF ENGLAND, 4 vols. in 1, strongly bound in cloth	5s.
————— Ditto, in half-morocco, gilt, marbled edges	5s. 6d.
HISTORY OF GREECE, 2 vols. in 1, bound in cloth	3s. 6d.
Ditto, in half-morocco, gilt, marbled edges	4s.
HISTORY OF ROME, 2 vols. in 1, bound in cloth	3s. 6d.
Ditto, in half-morocco, gilt, marbled edges	4s.
CHRONOLOGY OF CIVIL AND ECCLESIASTICAL HISTORY, LITERATURE, ART, &c., 2 vols. in 1, bound in cloth	3s. 6d.
————— Ditto, in half-morocco, gilt, and marbled edges	4s.
CLARKE'S DICTIONARY OF THE ENGLISH LANGUAGE, bound in cloth	4s. 6d.
—————, in half-morocco, gilt, marbled edges	5s.
—————, bound with Dr. CLARKE'S ENGLISH GRAMMAR, in cloth	5s. 6d.
————— Ditto, in half-morocco, gilt, marbled edges	6s.

HAMILTON'S GREEK AND ENGLISH and ENGLISH AND GREEK DICTIONARY, 4 vols. in 1, bound in cloth	5s.
Ditto, in half-morocco, gilt, marbled edges	5s. 6d.
Ditto, with the GREEK GRAMMAR, bound in cloth	6s.
Ditto, with Ditto, in half-morocco, gilt, marbled edges	6s. 6d.
GOODWIN'S LATIN AND ENGLISH and ENGLISH AND LATIN DICTIONARY, 2 vols. in 1, bound in cloth	4s. 6d.
Ditto, in half-morocco, gilt, marbled edges	5s.
Ditto, with the LATIN GRAMMAR, bound in cloth	5s. 6d.
Ditto, with Ditto, in half-morocco, gilt, marbled edges	6s.
ELWES'S FRENCH AND ENGLISH and ENGLISH AND FRENCH DICTIONARY, 2 vols. in 1, in cloth	3s. 6d.
Ditto, in half-morocco, gilt, marbled edges	4s.
Ditto, with the FRENCH GRAMMAR, bound in cloth	4s. 6d.
Ditto, with Ditto, in half-morocco, gilt, marbled edges	5s.
FRENCH AND ENGLISH PHRASE BOOK, or Vocabulary of all Conversational Words, bound, to carry in the pocket	1s. 6d.
ELWES'S ITALIAN, ENGLISH, AND FRENCH,—ENGLISH, ITALIAN, AND FRENCH,—FRENCH, ITALIAN, AND ENGLISH DICTIONARY, 3 vols. in 1, bound in cloth	7s. 6d.
ELWES's Ditto, in half-morocco, gilt, marbled edges	8s. 6d.
Ditto, with the GRAMMAR, bound in cloth	8s. 6d.
Ditto, with Ditto, in half-morocco, gilt, marbled edges	9s.
SPANISH AND ENGLISH and ENGLISH AND SPANISH DICTIONARY, 4 vols. in 1, bound in cloth	5s.
Ditto, in half-morocco, gilt, marbled edges	5s. 6d.
Ditto, with the GRAMMAR, bound in cloth	6s.
Ditto, with Ditto, in half morocco, gilt, marbled edges	6s. 6d.
HAMILTON'S ENGLISH, GERMAN, AND FRENCH,—GERMAN, FRENCH, AND ENGLISH,—FRENCH, GERMAN, AND ENGLISH DICTIONARY, 3 vols. in 1, bound in cloth	4s.
Ditto, in half-morocco, gilt, marbled edges	4s. 6d.
Ditto, with the GRAMMAR, bound in cloth	5s.
Ditto, with Ditto, in half-morocco, gilt, marbled edges	5s. 6d.
BRESSLAU'S HEBREW AND ENGLISH DICTIONARY, with the GRAMMAR, 3 vols. bound in cloth	12s.
Ditto, 3 vols., in half-morocco, gilt, marbled edges	14s.

Now in the course of Publication,

GREEK AND LATIN CLASSICS,

Price 1s. per Volume, (except in some instances, and those are 1s. 6d. or
2s. each), very neatly printed on good paper.

A Series of Volumes containing the principal Greek and Latin Authors,
accompanied by Explanatory Notes in English, principally selected from
the best and most recent German Commentators, and comprising all those

Works that are essential for the Scholar and the Pupil, and applicable for the Universities of Oxford, Cambridge, Edinburgh, Glasgow, Aberdeen, and Dublin,—the Colleges at Belfast, Cork, Galway, Winchester, and Eton, and the great Schools at Harrow, Rugby, &c.—also for Private Tuition and Instruction, and for the Library.

Those that are not priced are in the Press.

LATIN SERIES.

- | | | | |
|---|---------|--|---------|
| 1 A new LATIN DELECTUS, Extracts from Classical Authors, with Vocabularies and Explanatory Notes | 1s. | 9 TERENCE. Andria and Heautontimorumenos | 1s. 6d. |
| 2 CÆSAR'S COMMENTARIES on the GALLIC WAR; with Grammatical and Explanatory Notes in English, and a Geographical Index | 2s. | 10 TERENCE. Phormio, Adelphi and Hecyra | 1s. 6d. |
| 3 CORNELIUS NEPOS; with English Notes, &c. | 1s. | 11 CICERO. Orations against Catilina, for Sulla, for Archias, and for the Manilian Law | |
| 4 VIRGIL. The Georgics, Bucolics, and doubtful Works; with English Notes | 1s. | 12 CICERO. First and Second Philippics; Orations for Milo, for Marcellus, &c. | |
| 5 VIRGIL'S ÆNEID (on the same plan as the preceding) | 2s. | 13 CICERO. De Officiis | |
| 6 HORACE. Odes and Epodes; with English Notes, and Analysis and explanation of the metres | 1s. | 14 CICERO. De Amicitia, de Senectute, and Brutus | 1s. 6d. |
| 7 HORACE. Satires and Epistles, with English Notes, &c. | 1s. 6d. | 15 JUVENAL and PEASANTS. (The indecent passages expunged) | |
| 8 SALLUST. Conspiracy of Catilina, Jugurthine War | 1s. 6d. | 16 LIVY. Books I to v. in 2 parts | 3s. |
| | | 17 LIVY. Books xxi. and xxii. | 1s. |
| | | 18 TACITUS. Agricola; Germania; and Annals, Book I | |
| | | 19 Selections from TIBULLUS, OVID, PROPERTIUS, and LUcretius | |
| | | 20 Selections from STERONIX and the later Latin Writers | 1s. 6d. |

GREEK SERIES.

ON A SIMILAR PLAN TO THE LATIN SERIES.

- | | | | |
|---|---------|---|-----|
| 1 INTRODUCTORY GREEK READER. On the same plan as the Latin Reader | 1s. | 23 EURIPIDES; Hecuba | |
| 2 XENOPHON. Anabasis, i. ii. iii. | 1s. | 24 EURIPIDES; Medea | |
| 3 XENOPHON. Anabasis, iv. v. vi. vii. | 1s. | 25 EURIPIDES; Hippolytus | |
| 4 LUCIAN. Select Dialogues | 1s. | 26 EURIPIDES; Alcestis | |
| 5 HOMER. Iliad, I to vi. | 1s. 6d. | 27 EURIPIDES; Orestes | |
| 6 HOMER. Iliad, vii. to xii. | 1s. 6d. | 28 EURIPIDES. Extracts from the remaining plays | |
| 7 HOMER. Iliad, xiii. to xviii. | 1s. 6d. | 29 SOPHOCLES. Extracts from the remaining plays | |
| 8 HOMER. Iliad, xix. to xxiv. | 1s. 6d. | 30 ESCHYLUS. Prometheus Vinctus | |
| 9 HOMER. Odyssey, I to vi. | 1s. 6d. | 31 ESCHYLUS. Perse | |
| 10 HOMER. Odyssey, vii. to xii. | 1s. 6d. | 32 ESCHYLUS. Septem contra Thebas | |
| 11 HOMER. Odyssey, xiii. to xviii. | 1s. 6d. | 33 ESCHYLUS. Choephori | |
| 12 HOMER. Odyssey, xix. to xxiv.; and Hymns | 1s. 6d. | 34 ESCHYLUS. Eumenides | |
| 13 PLATO. Apology, Crito, and Phædo | 1s. | 35 ESCHYLUS. Agamemnon | |
| 14 HERODOTUS, I. II. | 1s. | 36 ESCHYLUS. Supplices | |
| 15 HERODOTUS, ill. to iv. | 1s. | 37 PLUTARCH. Select Lives | |
| 16 HERODOTUS, v. vi. and part of vii. | 1s. | 38 ARISTOPHANES. Clouds | |
| 17 HERODOTUS. Remainder of vii. viii. and ix. | 1s. | 39 ARISTOPHANES. Frogs | |
| 18 SOPHOCLES; Oedipus Rex. | 1s. | 40 ARISTOPHANES. Selections from the remaining Comedies | |
| 19 SOPHOCLES; Oedipus Coloneus. | 1s. | 41 THUCYDIDES, I. | 1s. |
| 20 SOPHOCLES; Antigone. | 1s. | 42 THUCYDIDES, II. | |
| 21 SOPHOCLES; Ajax. | 1s. | 43 THEOCRITUS. Select Idyls | |
| 22 SOPHOCLES; Philoctetes. | 1s. | 44 PINDAR. | |
| | | 45 ISOCRATES. | |
| | | 46 HESIOD. | |

LONDON : JOHN WEALE, 59, HIGH HOLBORN.
WHOLESALE AGENTS, LOCKWOOD & CO., 7, STATIONERS' HALL COURT, E.C.

USEFUL ARITHMETICAL WORKS, BY DANIEL O'GORMAN.
INTUITIVE CALCULATIONS;

The most Concise Methods ever published. Designed for the use of all Classes—Bankers, Brewers, Engineers, Land Surveyors, Manufacturers, Merchants, Wine and Spirit Merchants, Timber Merchants, Professors, Teachers, &c. With an Appendix on Decimal Computation, Coins, and Currency. By DANIEL O'GORMAN. 22nd Edition, revised by a Licentiate of the College of Preceptors. 30th Thousand, crown 8vo, 3s. 6d. cloth.

AN ORIGINAL AND COMPREHENSIVE SYSTEM OF SELF-INSTRUCTING BOOK-KEEPING BY SINGLE AND DOUBLE ENTRY. New Edition, 8vo, price 5s. cloth.

THE PRINCE OF WALES'S NEW TABLE-BOOK, compiled from the "Intuitive Calculations;" embracing all the Tables in Money, Weights, and Measures, necessary for the Arithmetician; with New Tables of Decimal Coins. New Edition, 12mo, 8d. stitched.

WORKS BY THE REV: WM. HARRISON, RECTOR OF BIRCH.
THE TONGUE OF TIME;

Or, the Language of a Church Clock. By WILLIAM HARRISON, A.M. of Brasenose College, Oxford; Domestic Chaplain to H.R.H. the Duke of Cambridge; Rector of Birch, Essex. 6th Edition, with beautiful Frontispiece, feap., reduced to 3s. cloth, gilt edges.

"This is a spiritual little treatise, intended to improve practically and devotionally the twelve hours of the day to the edification of the soul."—*Churchman's Monthly Review*.

THE SHEPHERD AND HIS SHEEP;

AN EXPOSITION OF THE TWENTY-THIRD PSALM.

2nd Edition, enlarged, feap., reduced to 2s. 6d. cloth, gilt edges.

CONSECRATED THOUGHTS;

OR, A FEW NOTES FROM A CHRISTIAN HARP.

2nd Edition, corrected, feap., 2s. 6d. cloth, gilt edges.

SERMONS ON THE COMMANDMENTS,

PREACHED IN THE CHAPEL OF THE MAGDALEN HOSPITAL.

2nd Edition, corrected, feap., 4s. cloth.

MANUAL FOR THE BEREAVED:

2nd Edition, feap., reduced to 4s. 6d. cloth.

HOURS OF SADNESS;

Or, Instruction and Comfort for the Mourner: consisting of a Selection of Devotional Meditations, Instructive and Consolatory Reflections, Letters, Prayers, Poetry, &c., from various Authors, suitable for the bereaved Christian.

Cheap and Entertaining Books for Children.

THE STORY OF THE THREE BEARS. 17th Edition, with Illustrations, oblong, now reduced to 6d. sewed.

THE GREAT BEAR'S STORY; or, the Vizier and the Woodman. With Illustrations, oblong, now reduced to 6d. sewed.

AN HOUR AT BEARWOOD; or, The Wolf and the Seven Kids. With Illustrations, oblong, now reduced to 6d. sewed.

THE THREE BEARS AND THEIR STORIES; being the above Stories in 1 vol., with numerous Illustrations, reduced to 2s. oblong, cloth lettered.

THE UGLY DUCK. By HANS ANDERSEN. Versified; and dedicated to the Readers of "The Three Bears." Four Illustrations by WEIGALL. Oblong, now reduced to 6d. sewed.

ELEGANT CHRISTMAS, NEW YEAR'S, AND BIRTHDAY GIFTS.

Ninth Edition, fcap. 8vo, cloth, gilt edges, 568 pp., price 6s.,

TRUTHS ILLUSTRATED BY GREAT AUTHORS.

A Dictionary of nearly Four Thousand Aids to Reflection, Quotations of Maxims, Metaphors, Counsels, Cautions, Proverbs, Aphorisms, &c. &c. In Prose and Verse. Compiled from Shakespeare and other Great Writers.

"An achievement worthy of the highest order of literary genius."—*Morning Advertiser*.

"The quotations are perfect gems; their selection evinces sound judgment and an excellent taste."—*Dispatch*.

"We accept the treasure with profound gratitude—it should find its way to every home."—*Era*.

"We know of no better book of the kind."—*Examiner*.

Third Edition, fcap. 8vo, cloth, gilt edges, 536 pp., price 6s.,

THE BEAUTY OF HOLINESS;

Or, the Practical Christian's Daily Companion: being a Collection of upwards of Two Thousand Reflective and Spiritual Passages, Remarkable for their Sublimity, Beauty, and Practicability; selected from the Sacred Writings, and arranged in Eighty-two Sections, each comprising a different Theme for Meditation. By the Editors of "Truths Illustrated by Great Authors."

Second Edition, fcap. 8vo, cloth, gilt edges, nearly 700 pages, with beautiful Vignette Title, price 6s.,

THE

PHILOSOPHY OF WILLIAM SHAKESPEARE.

Delineating, in Seven Hundred and Fifty Passages selected from his Plays, the Multi-form Phases of the Human Mind. With Index and References. Collated, Elucidated, and Alphabetically arranged, by the Editors of "Truths Illustrated by Great Authors."

Second Edition, fcap. 8vo, cloth, gilt edges, 638 pages, with beautiful tinted lithograph Frontispiece and Title, after the design of Moritz Retsch, price 6s.,

SONGS OF THE SOUL,

During its Pilgrimage Heavenward: being a New Collection of Poetry, illustrative of the Power of the Christian Faith. Selected from the Works of the most eminent British, Foreign, and American Writers, Ancient and Modern, Original and Translated. By the Editors of "Truths Illustrated by Great Authors," "The Beauty of Holiness," &c. &c.

THE SUNBEAM STORIES.

Now ready, the Thirty-second Edition, price 1s.,

A TRAP TO CATCH A SUNBEAM.

Also by the same Author,

"COMING HOME." 2s. cloth gilt (just published).

THE DREAM CHINTZ. Illustrated by JAMES GODWIN. 2s. 6d., with a beautiful fancy cover.

OLD JOLLIFFE, not a Goblin Story. 1s.

THE SEQUEL TO "OLD JOLLIFFE." 1s.

THE HOUSE ON THE ROCK. 1s.

"ONLY;" a Tale for Young and Old. 1s.

THE CLOUD WITH THE SILVER LINING.

"A MERRY CHRISTMAS." 1s. [1s.

THE STAR IN THE DESERT. 1s.

SIBERT'S WOLD; or, CROSS PURPOSES.

Second Edition, 3s. 6d. cloth.

"In telling a simple story, and in the management of dialogue, the Author is excelled by few writers of the present day."—*Literary Gazette*.

